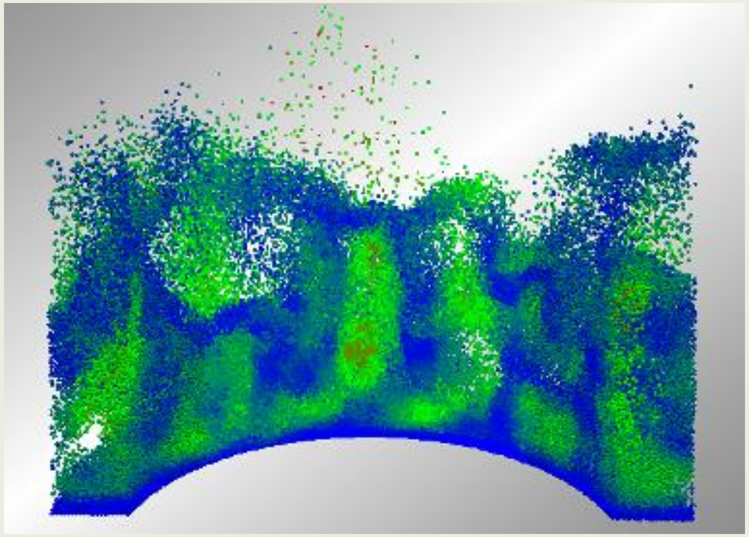
Fluidization

University of Pécs

Institute of Pharmaceutical Technology and Biopharmacy

Theory of Fluidization



Different solid systems in the pharmaceutical technology

powders

agglomerates

granules

pellets

Theory of Fluidization

In pharmaceutical practice can be:

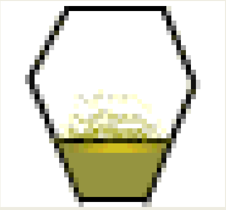
Granules may be created by

1. **Aggregation** from smaller particles - building up granulation (wet, melt granulation), or

2. **Desaggregation** from larger particles e.g. briquette (compaction, dry granulation)

Theory of Fluidization

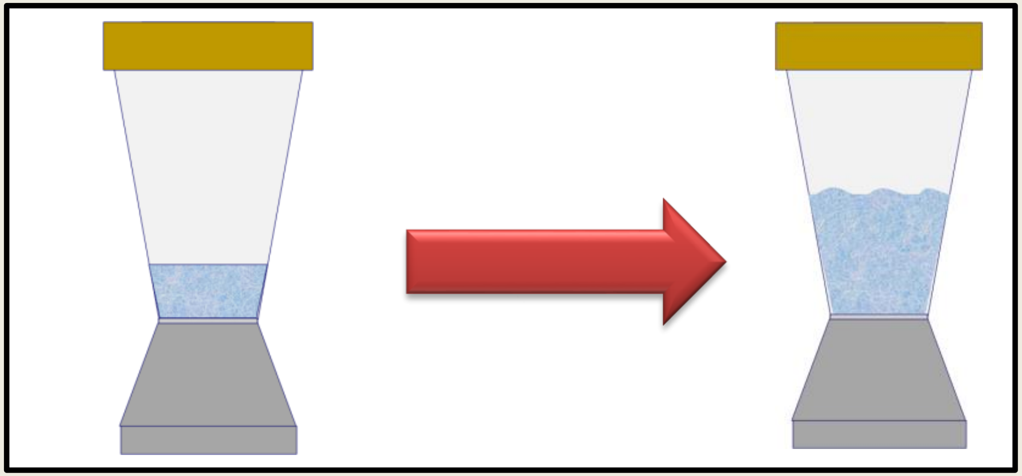
Definition



Fluidization is the **operation** by which fine solids are transformed into a **fluidlike** state through contact with a gas or liquid.

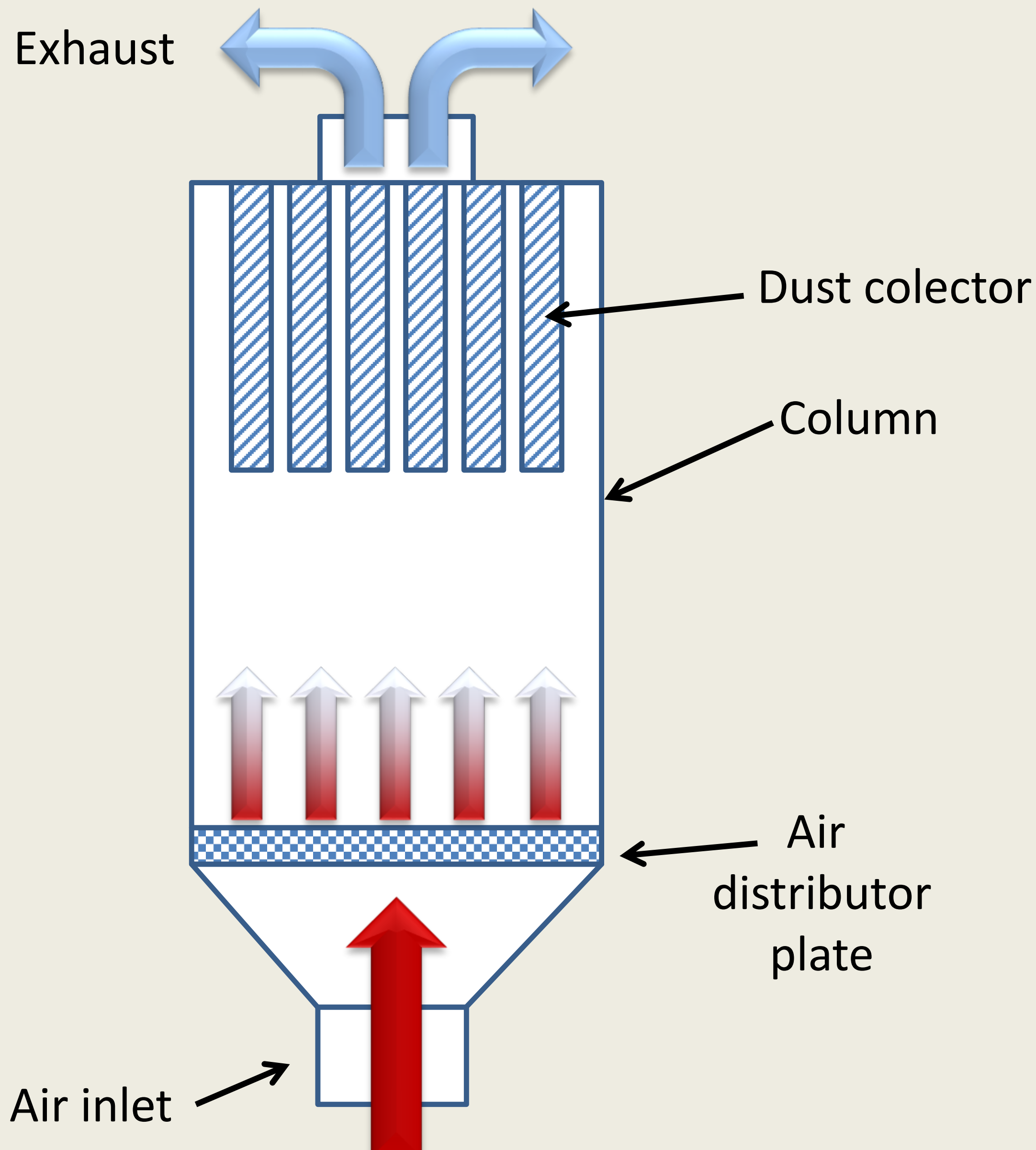
A material is converted **from a static solid-like state to a dynamic fluid-like state.**

This process occurs when a fluid (liquid or gas) is passed up through a solid material (ie. powders, granules, tabletts).



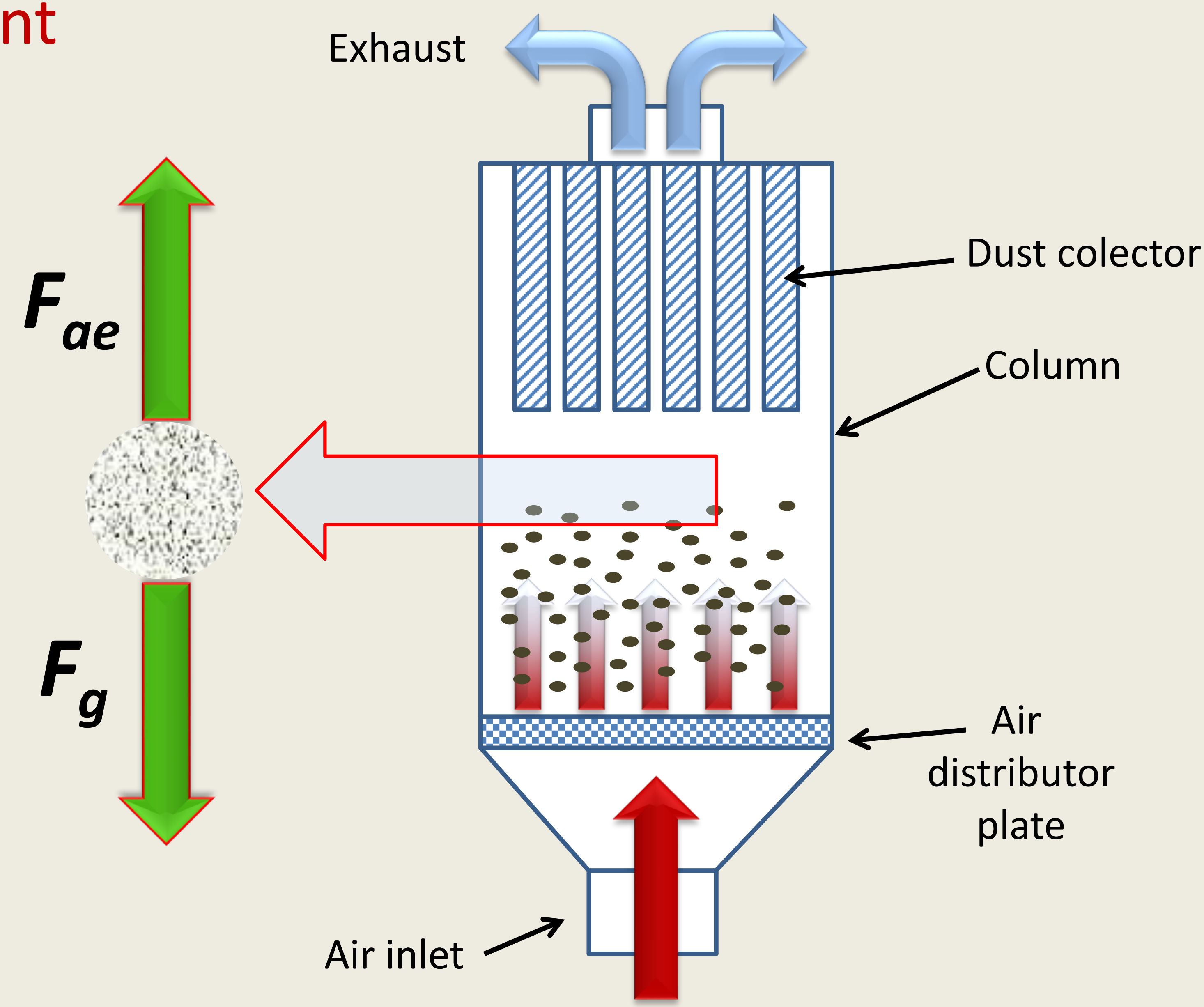
Theory of Fluidization

Equipment



Theory of Fluidization

Equipment



Theory of Fluidization

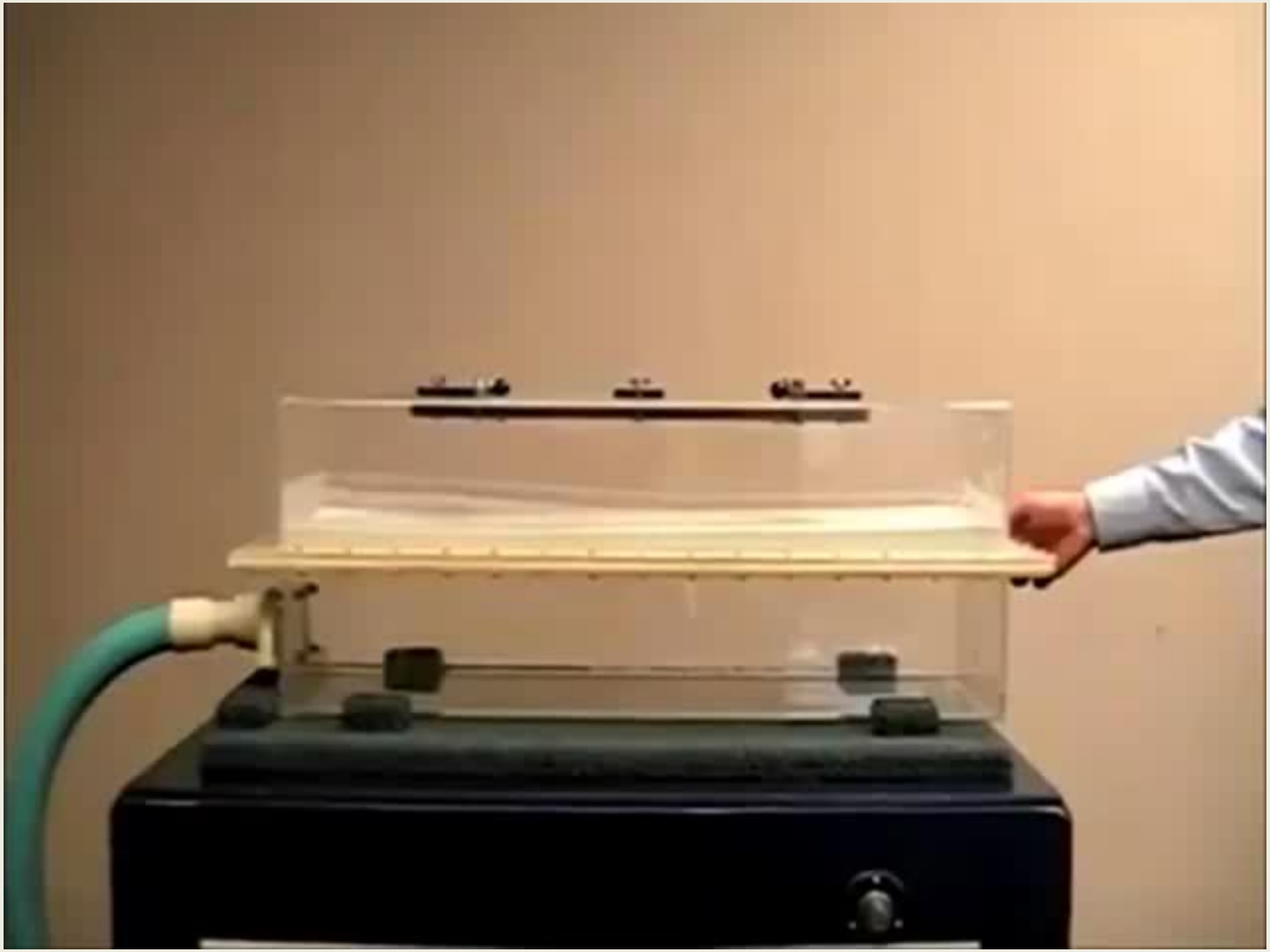
Before fluidization

Fluidization
(like boiling water)

Theory of Fluidization

Buoyancy, surface tension, viscosity…

Theory of Fluidization

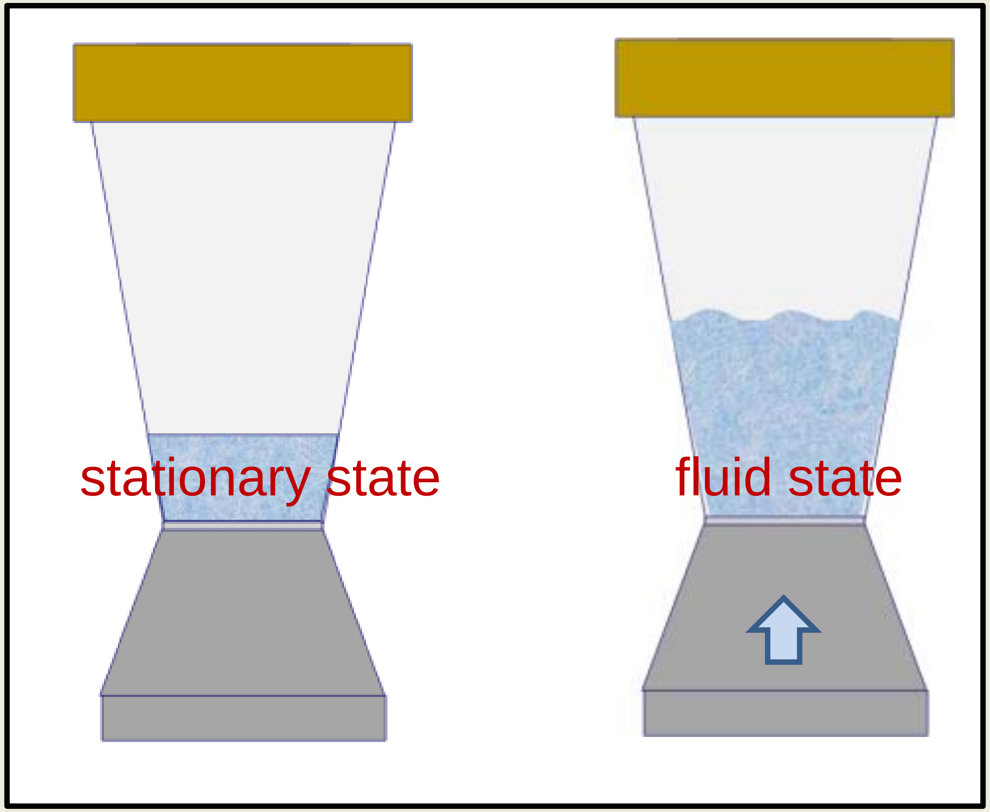


"Water Level„ pourable

Theory of Fluidization

The formation of fluid state

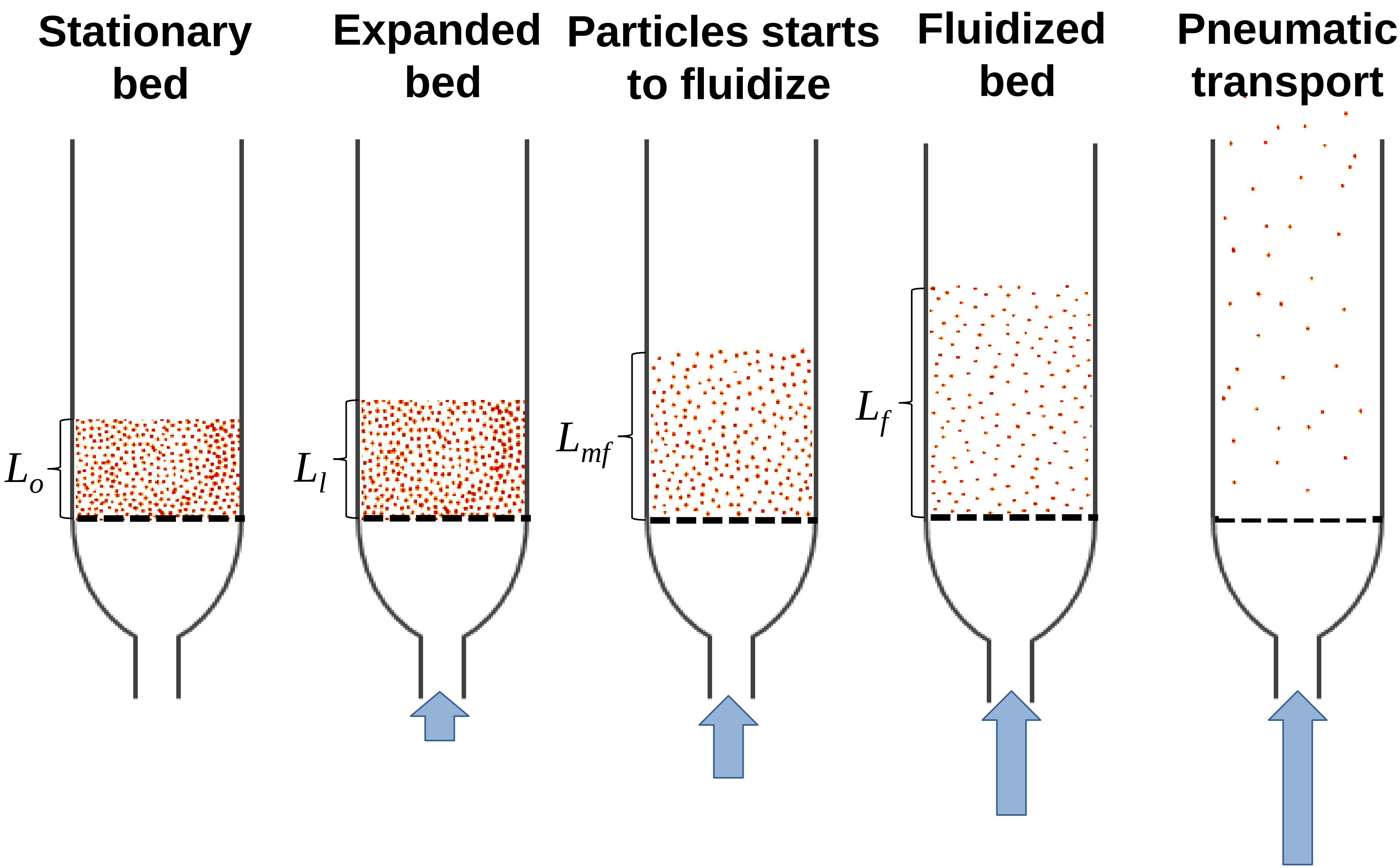
The particles in the bed can be expanded by increasing air (fluidum) speed till the point, of starting of fluidization.



In the fluid state surface of the bed begins to wave (fluctuate). The system seems like a boiling liquid.

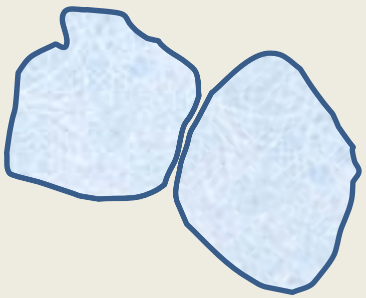
Theory of Fluidization

The effect of the fluidum speed to the behaviour of the system



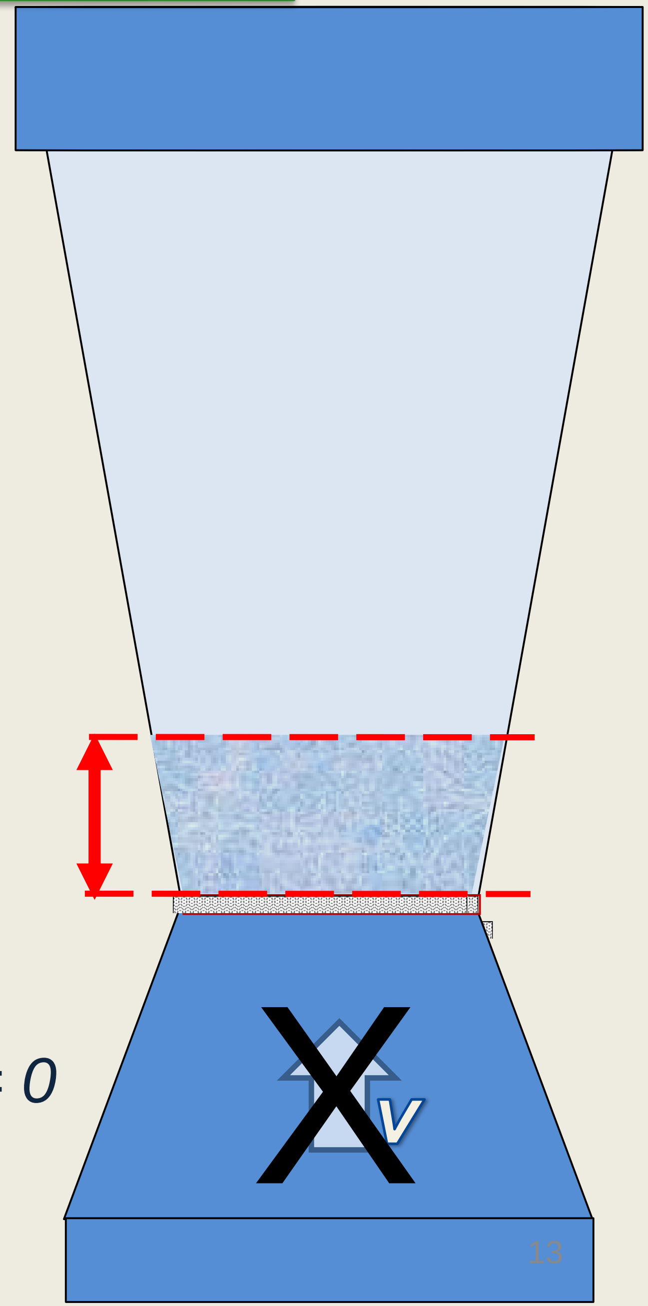
Theory of Fluidization

Stationary-bed



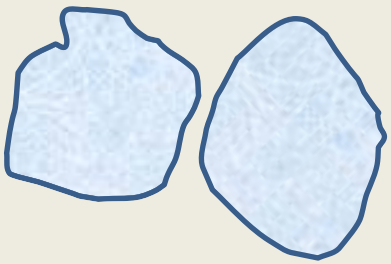
height of the fixed-bed (L_o)

speed of the fluidum $v = 0$



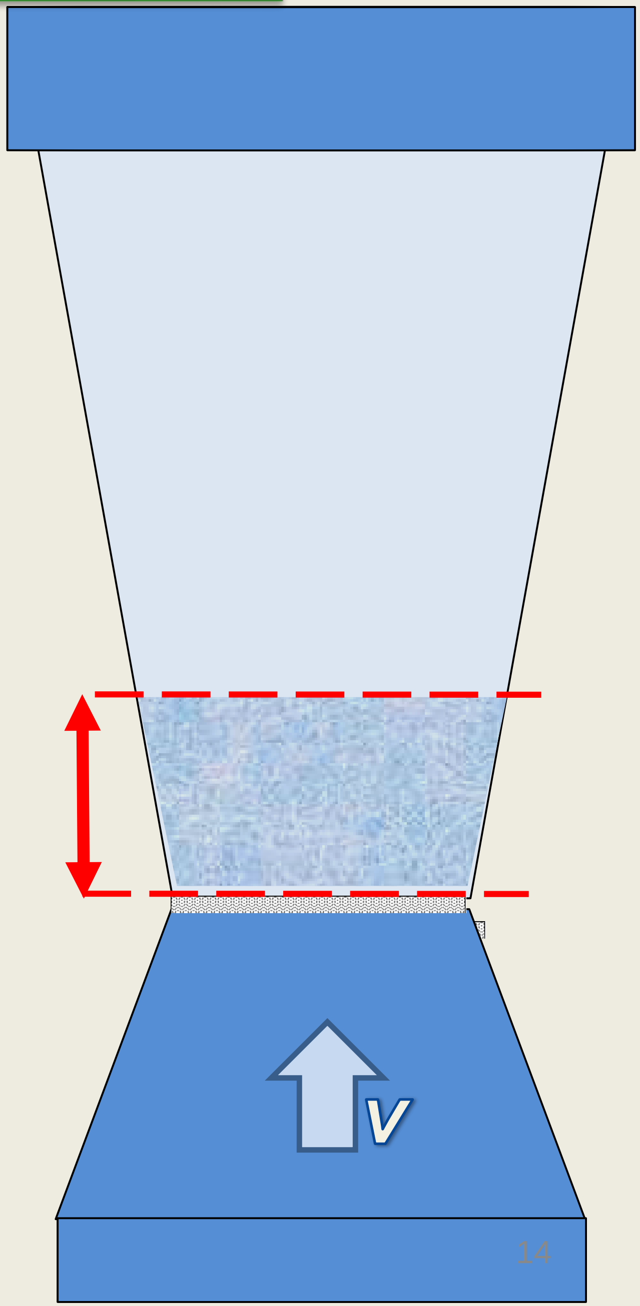
Theory of Fluidization

Loosen-bed



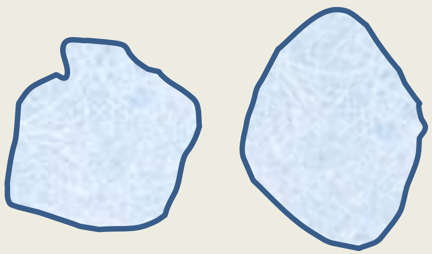
height of the loosen-bed (L_o)

speed of the fluidum (v_l)



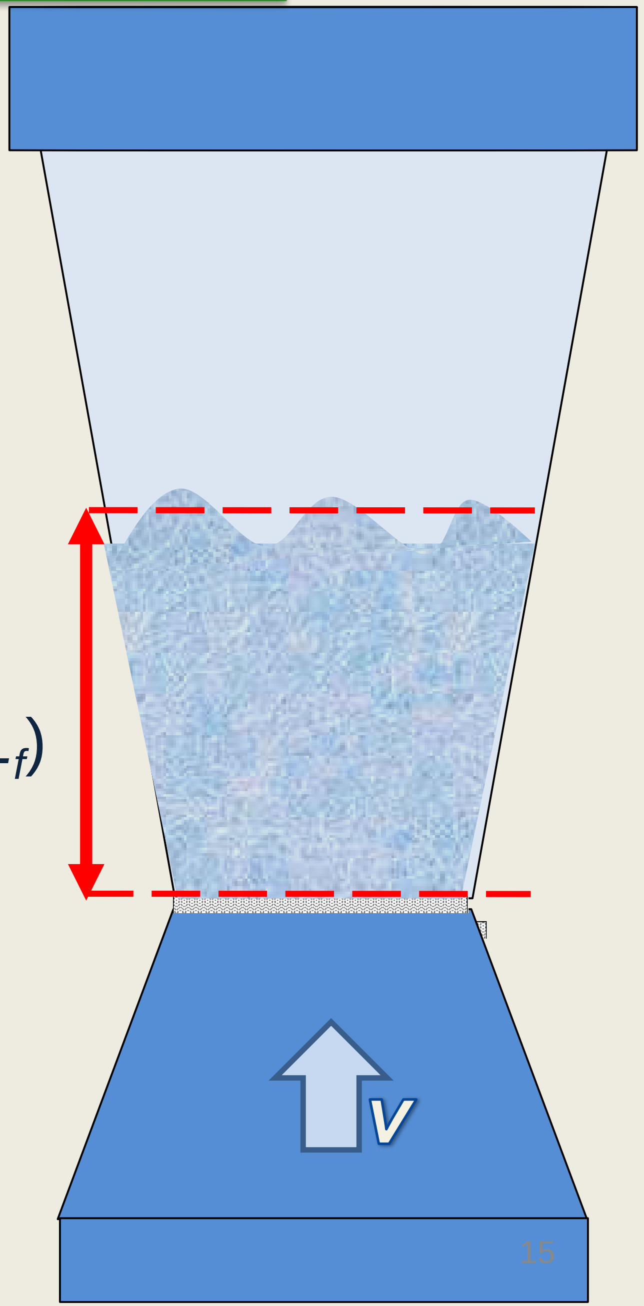
Theory of Fluidization

Fluid bed



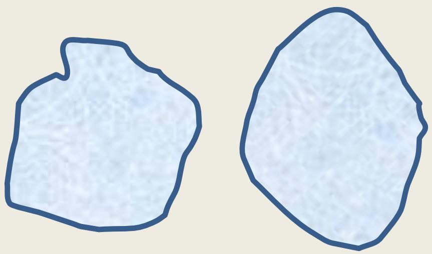
heihgt of
(tumbling) fluid bed (L_f)

speed of the fluidum (v_f)

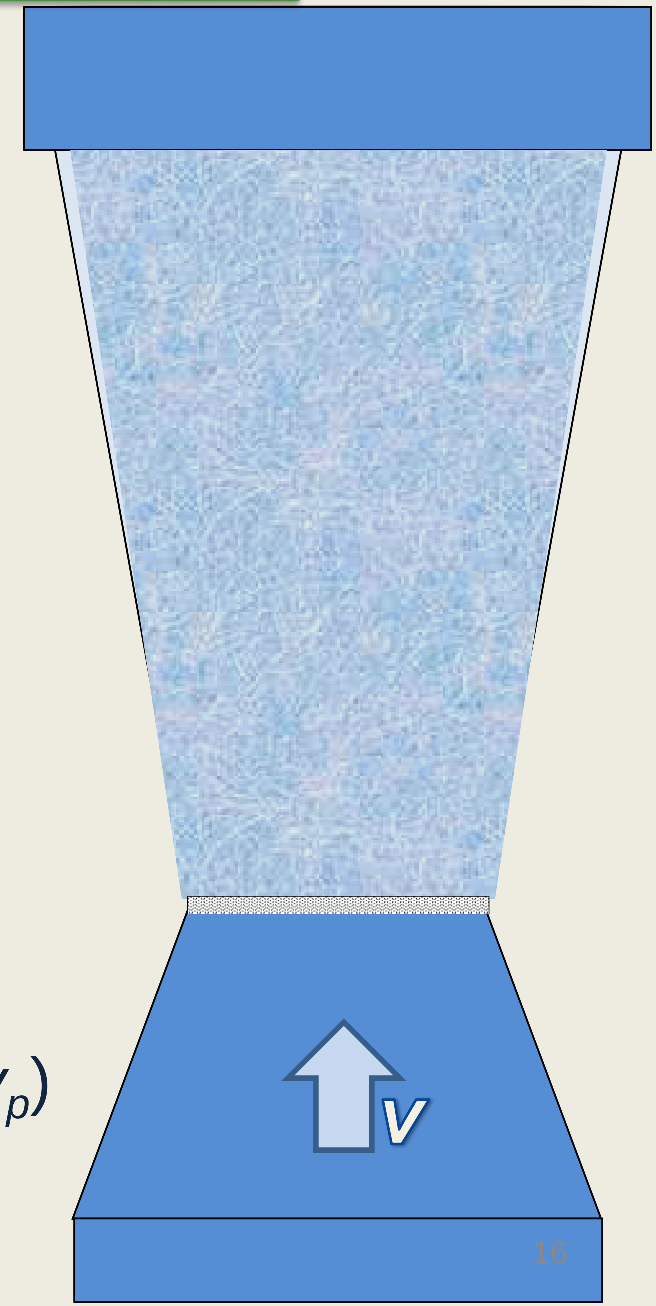


Theory of Fluidization

Pneumatic transport

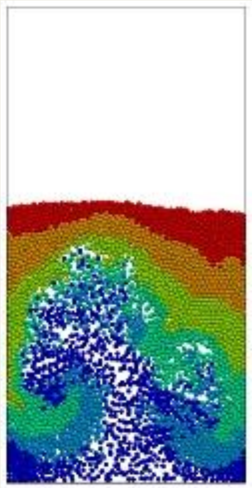


speed of the fluidum (v_p)



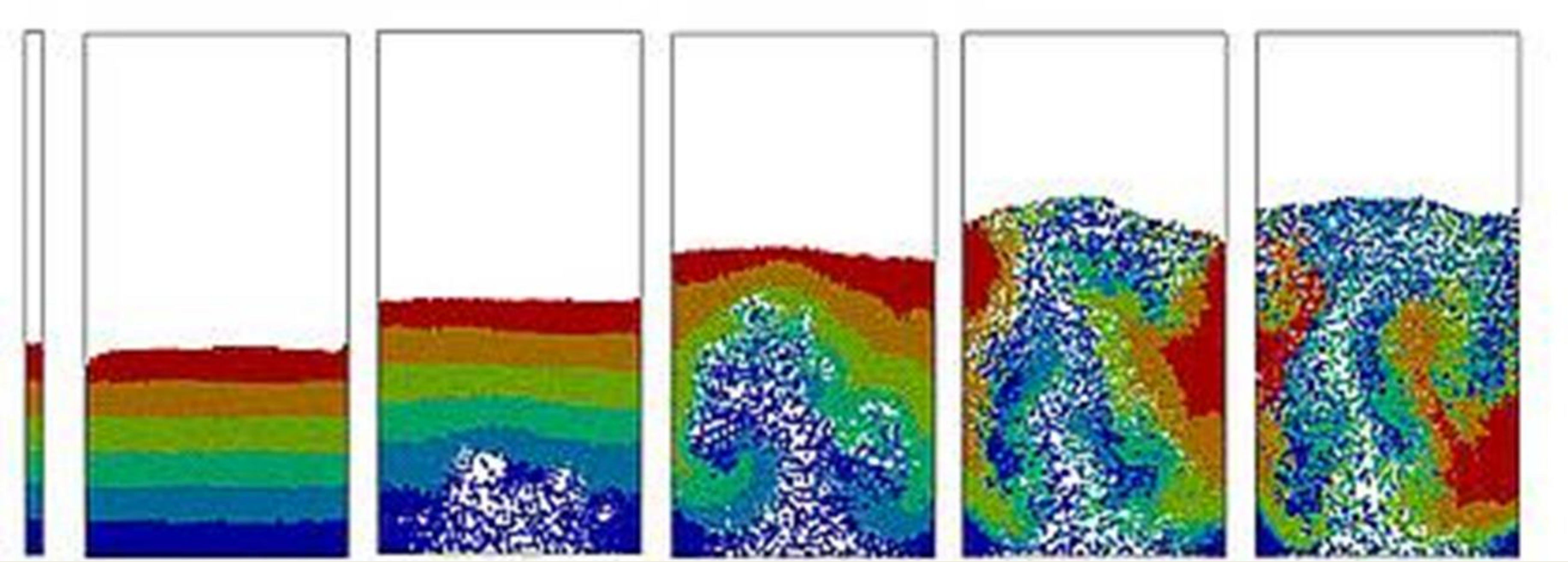
Investigation
of
the fluid bed

Fluidization disorders



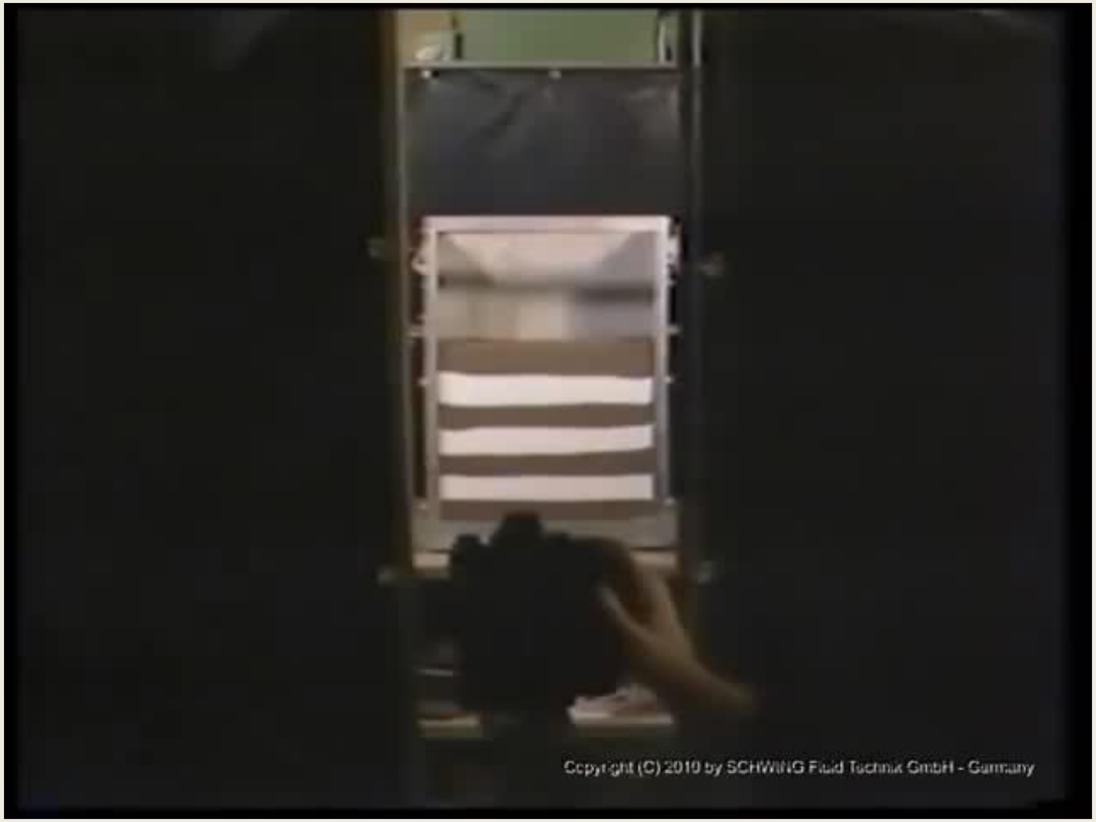
Theory of Fluidization

Disorders

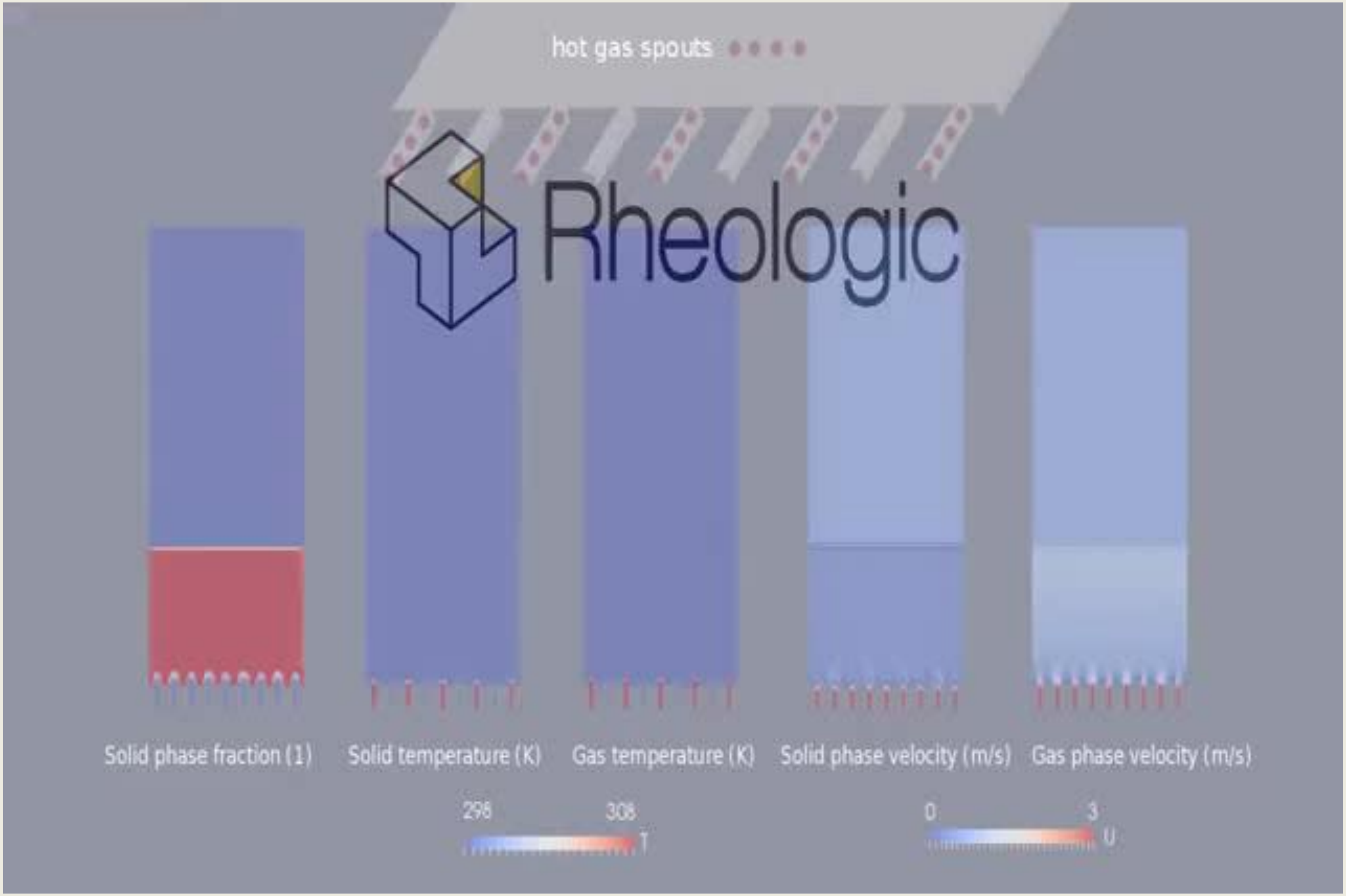


Snapshots of fluidization: particle positions at different points in time.

Theory of Fluidization

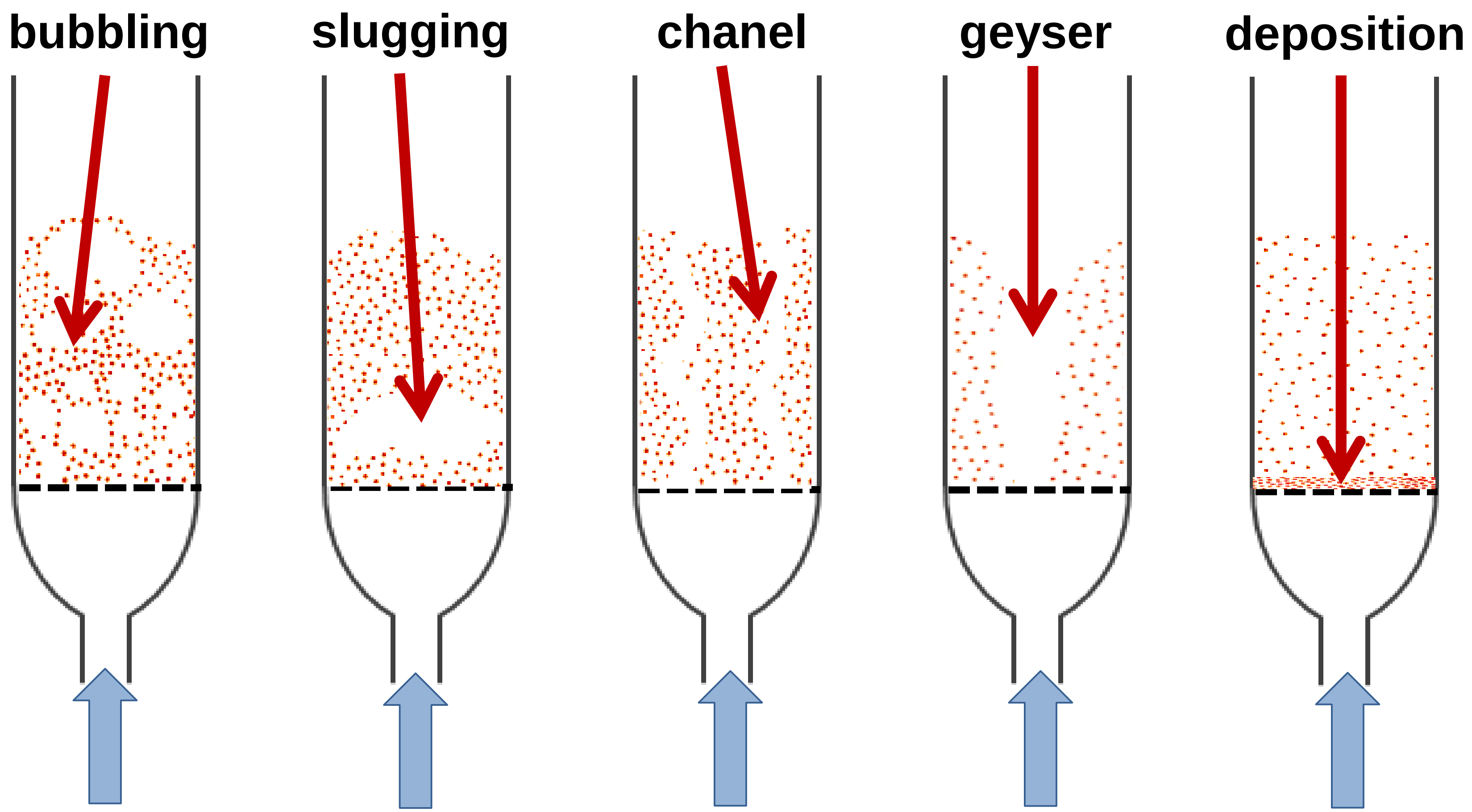


Theory of Fluidization



Theory of Fluidization

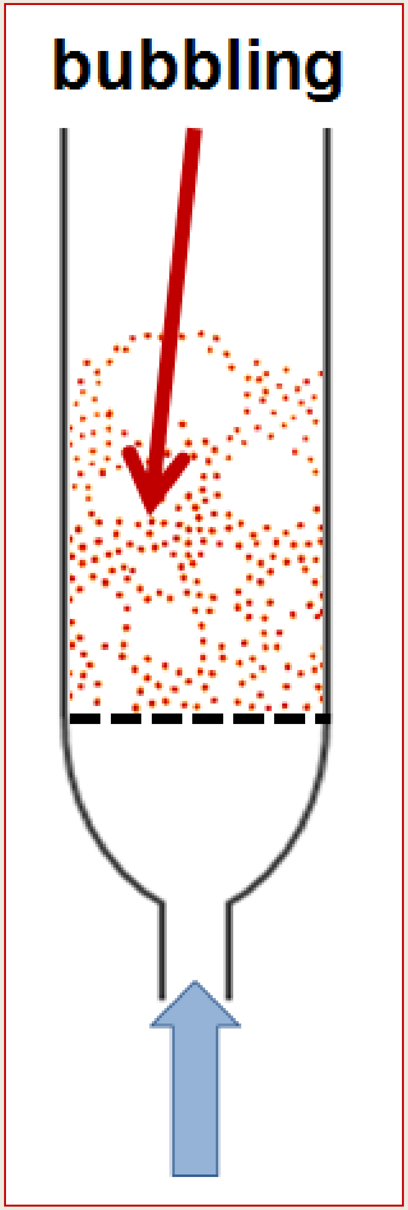
Disorders



Theory of Fluidization

Disorders

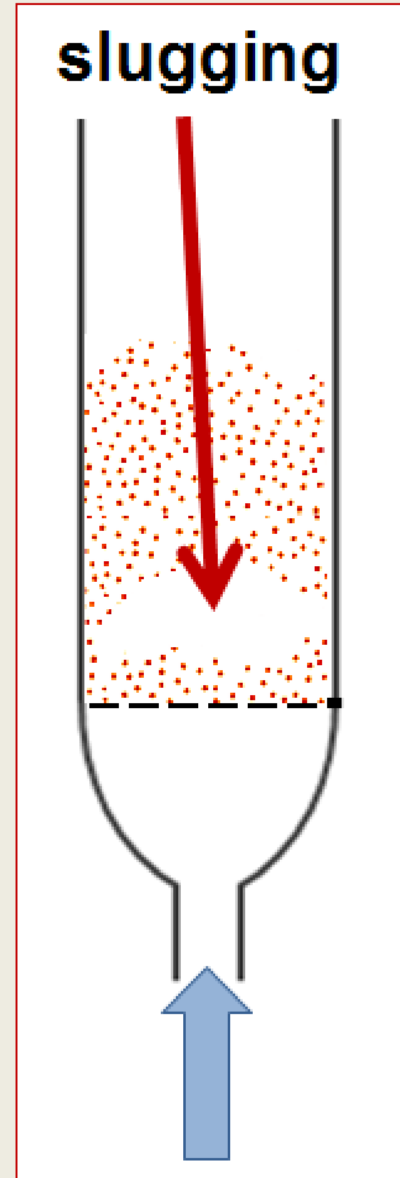
Bubble formation



Theory of Fluidization

Disorders

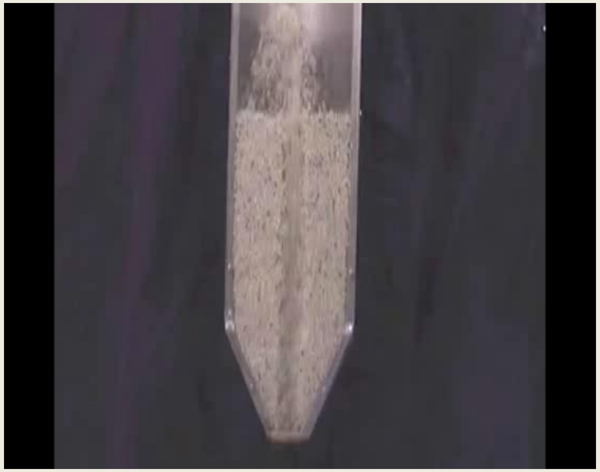
Slugging

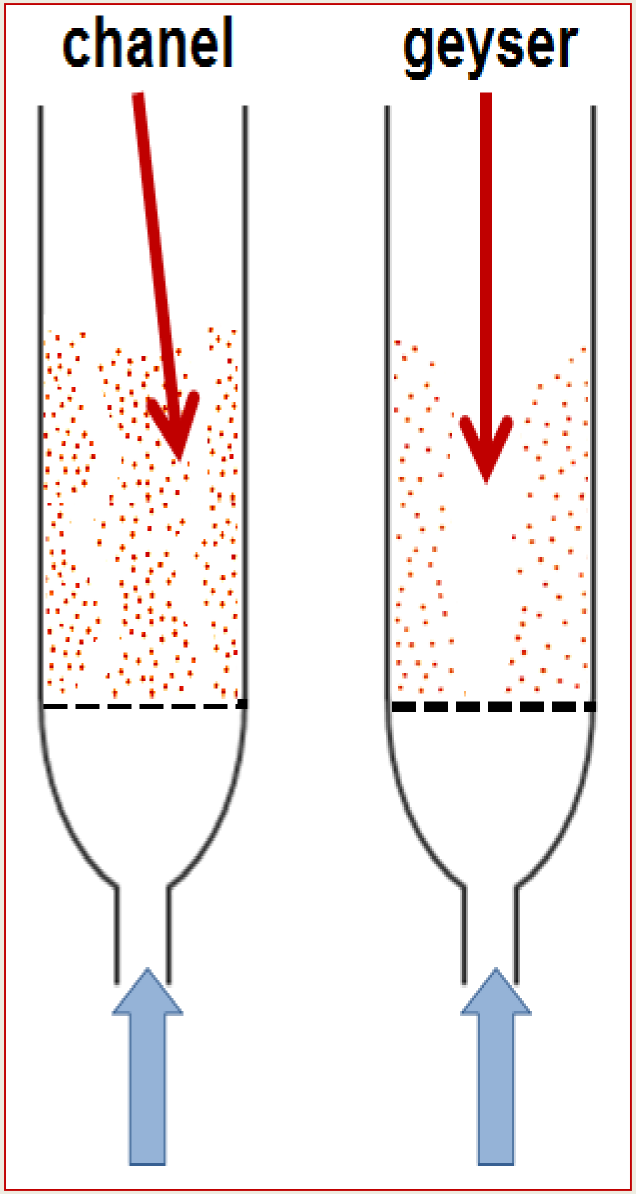


Theory of Fluidization

Disorders

Channel, geyser formation

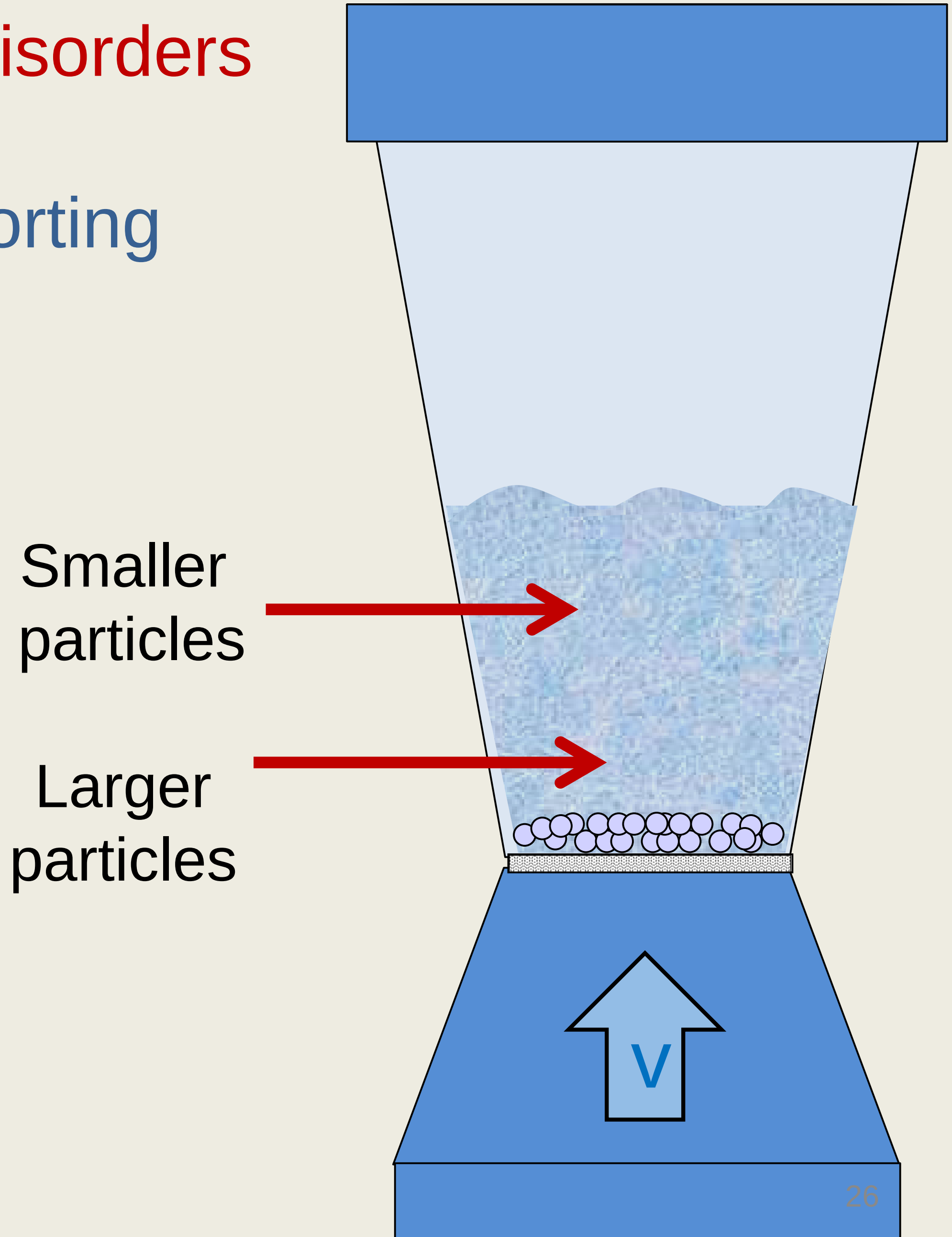


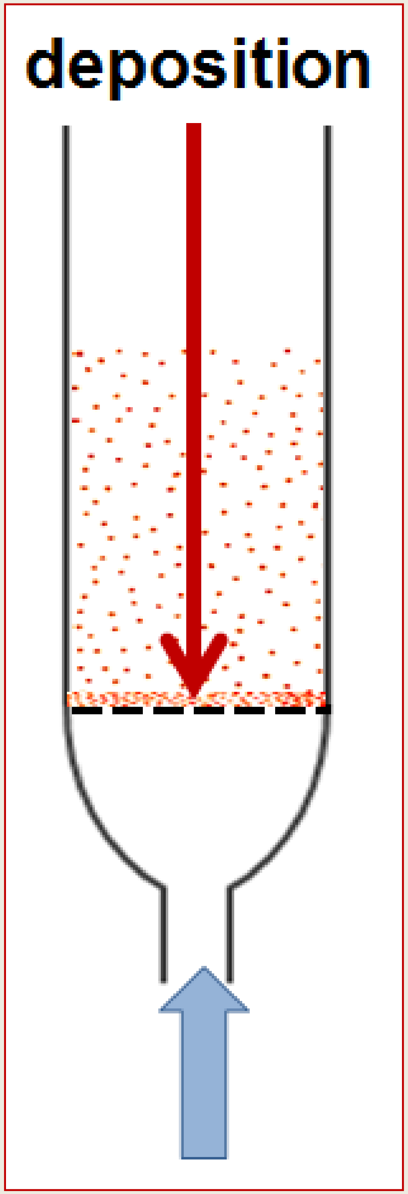


Theory of Fluidization

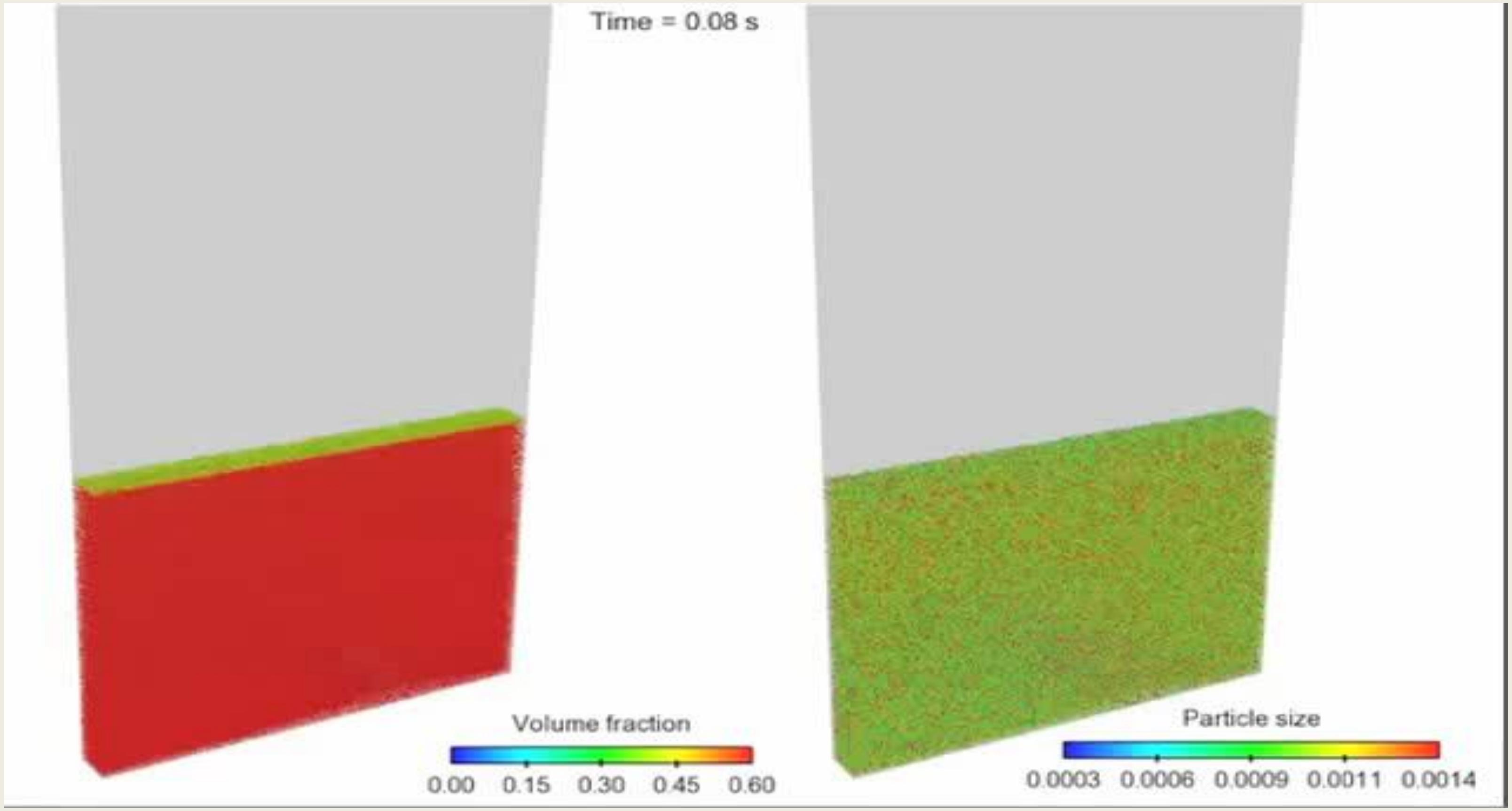
Disorders

sorting





Theory of Fluidization



Particle positions at different points in time.

Operation parameters of fluidization

Parameters of Fluidization

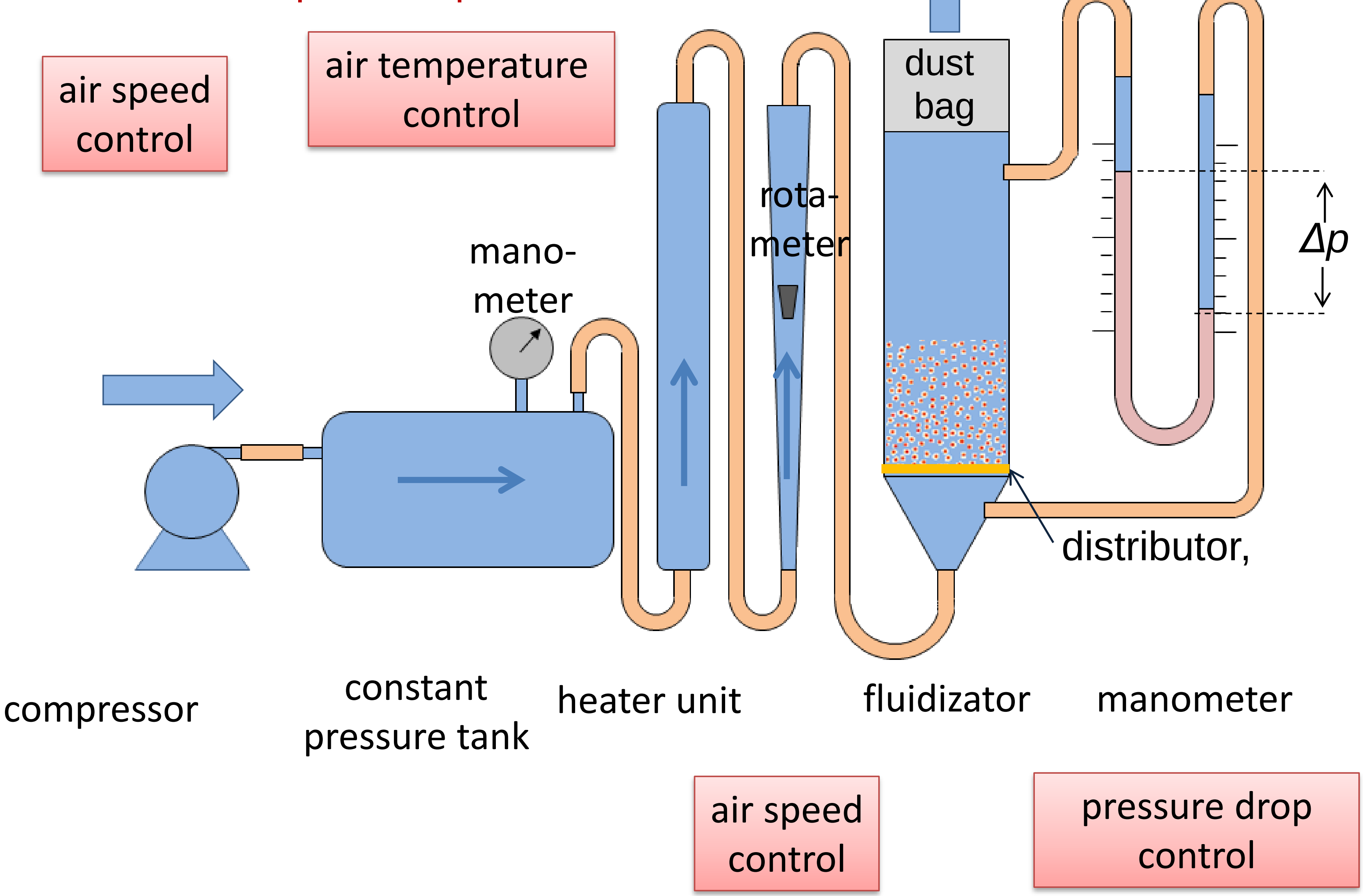
The mean operation parameters of the process

Independent variables

- mass of content (m),
- geometry and volume of the fluid-bed reactor,
- the properties of the base plate (sieve),
- speed of air,
- pressure of air,
- speed and pressure of the spraying (injector) air.

Parameters of Fluidization

Examination of the operation parameters



Parameters of Fluidization

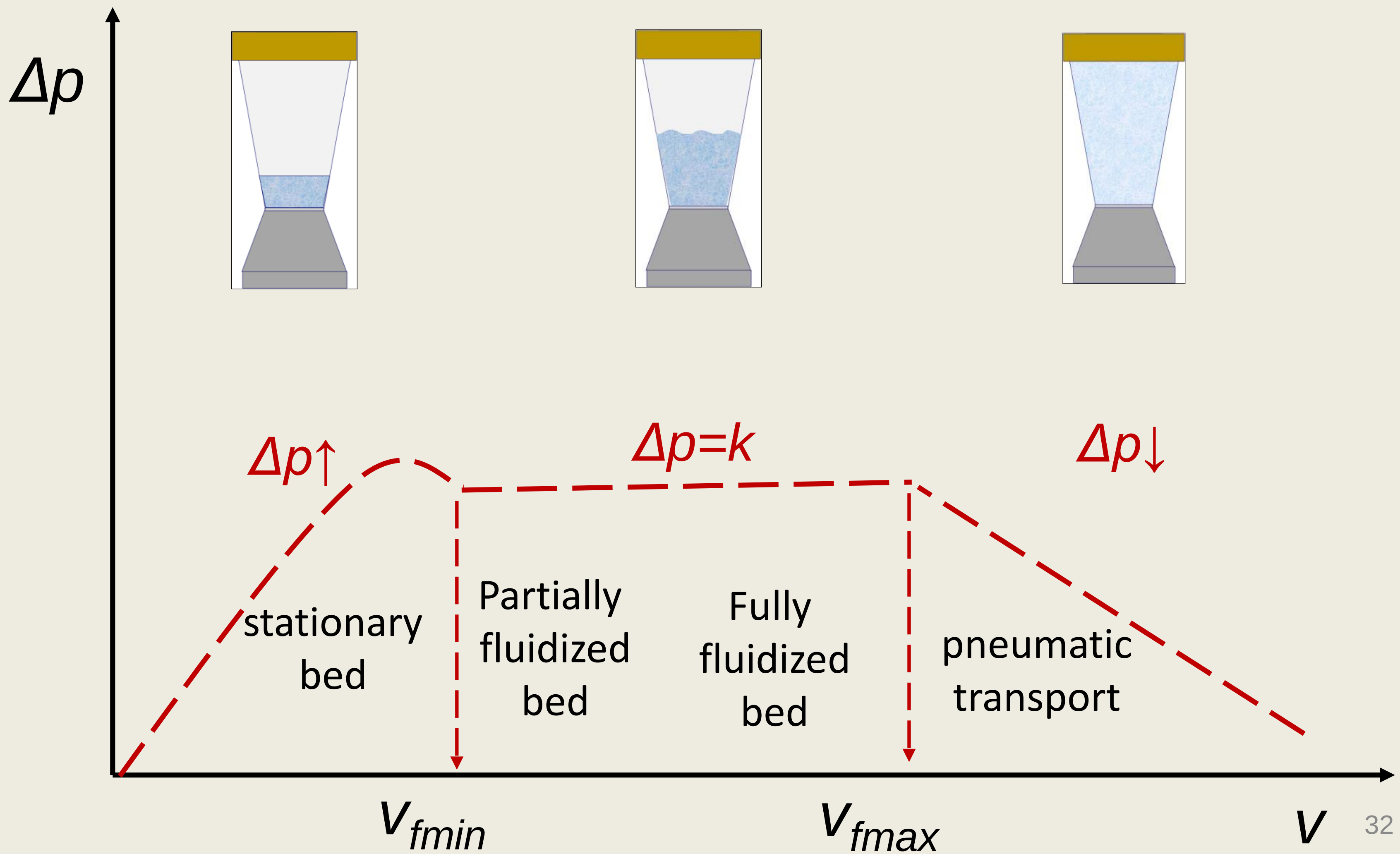
The mean operation parameters of the process

Dependent variables

- pressure drop (Δp),
- height of the bed (L),
- viscosity of the bed (η),
- minimum of the fluidization velocity (v_{fmin}),
- material loss, delivery of fine powders(m_k).

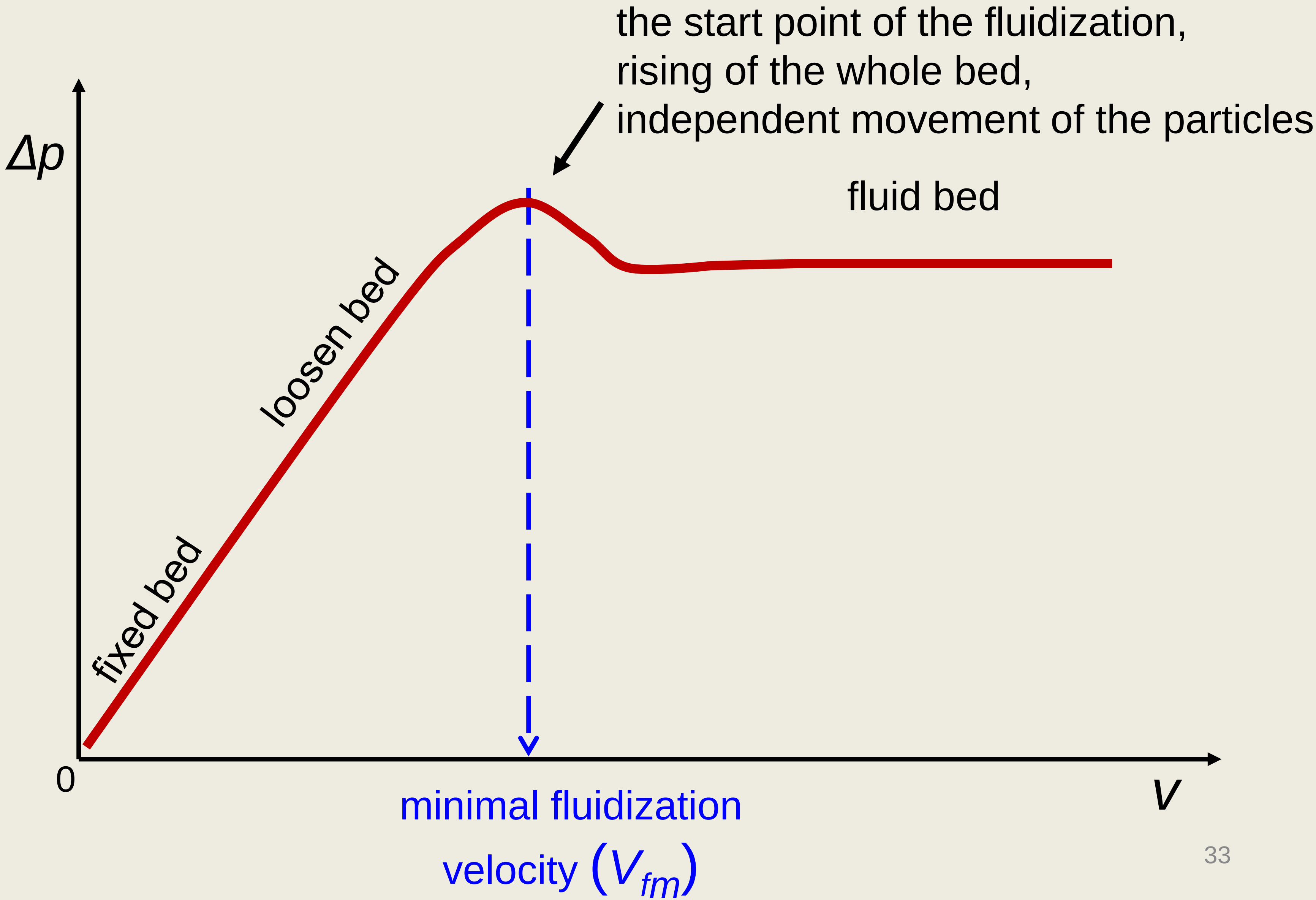
Parameters of Fluidization

The pressure drop of the fluidum against the fluid air velocity



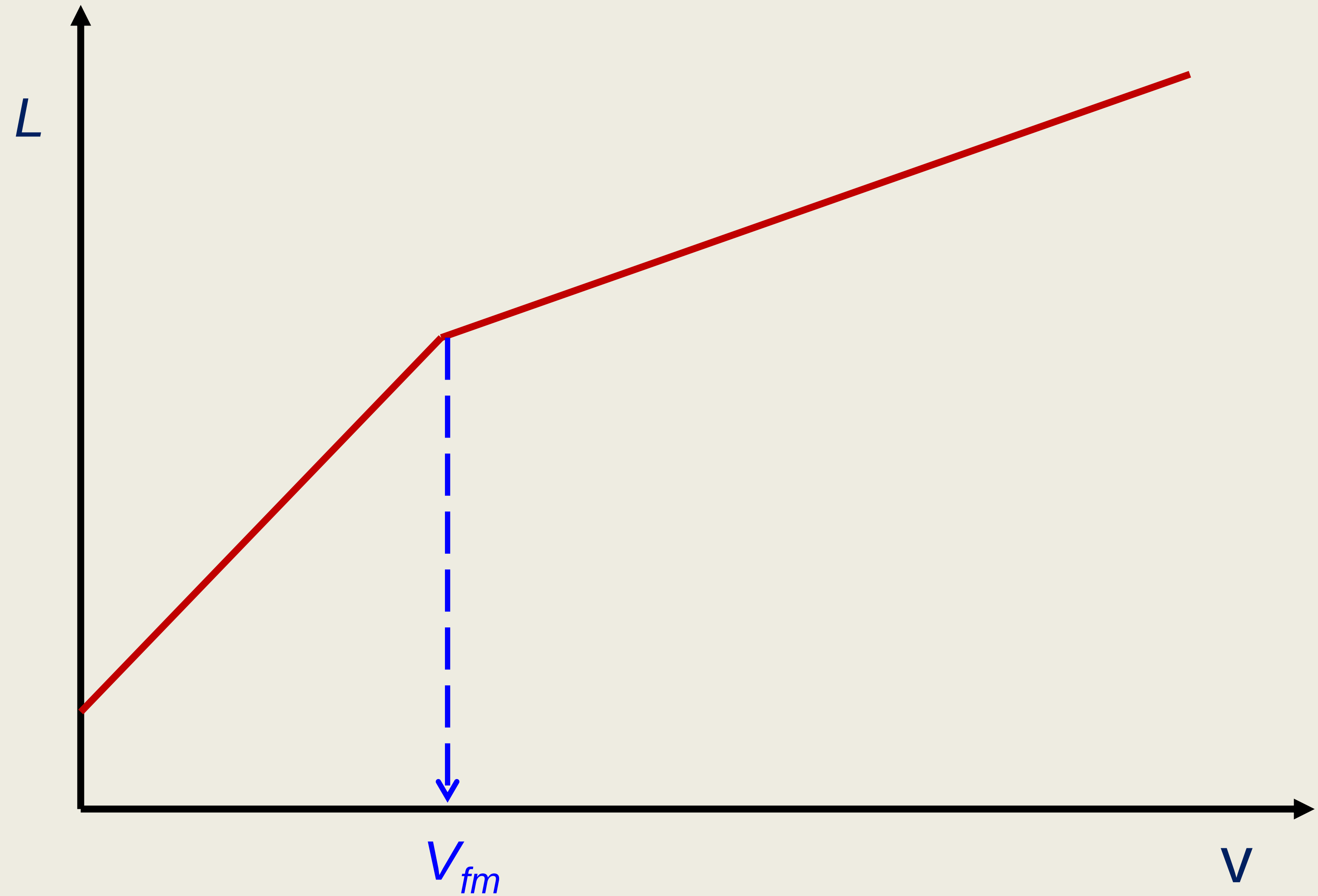
Parameters of Fluidization

Pressure drop during the initial phase



Parameters of Fluidization

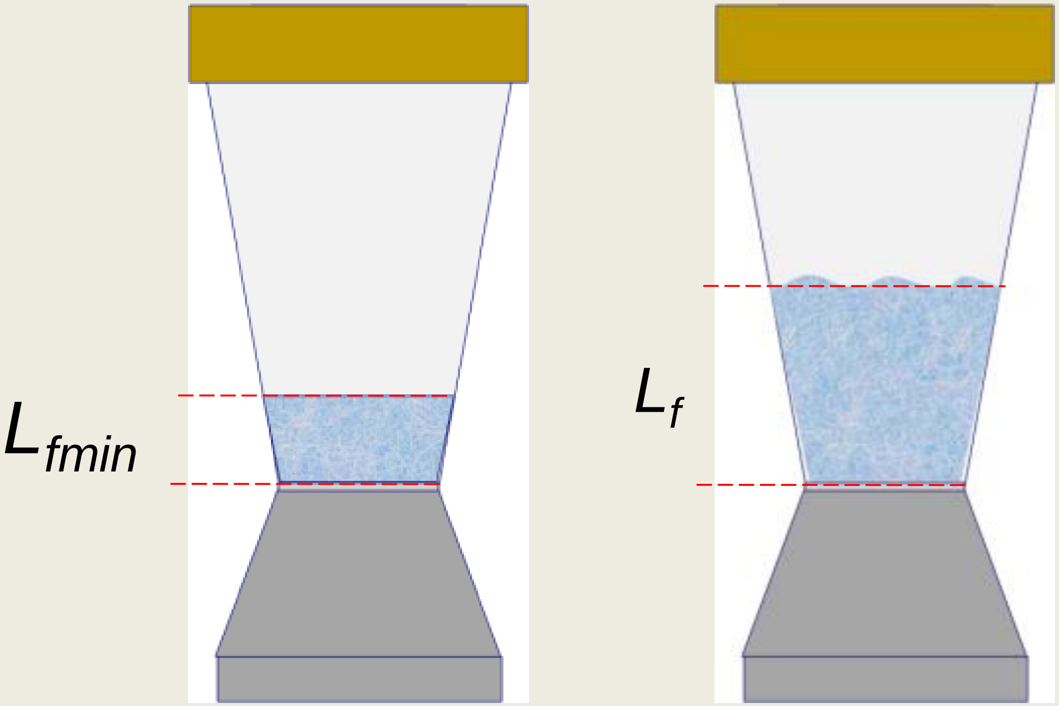
Changing of the bed-height (*L*) in the fluid bed



Parameters of Fluidization

Ratio of beds(*R*)

$$R = \frac{L_f}{L_{f\,\min}}$$



L_f height of the fluid bed

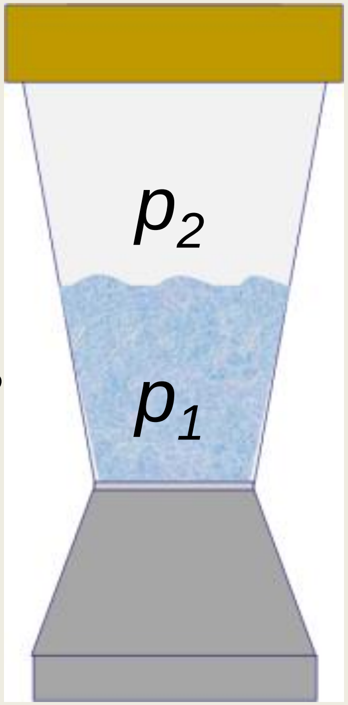
L_{fmin} the height of the minimal fluidized bed ($V = V_{fmin}$)

Parameters of Fluidization

The pressure drop (*Δp*)

$$\Delta p = L(1-\varepsilon)(\rho_{sz}-\rho_f)g$$

$\Delta p = p_1 - p_2$



L *height of the fluid bed*

ε porosity (or void fraction)

ρ_{sz} *density of fixed bed*

ρ_f *density of the fluid bed*

g *gravity force*

Parameters of Fluidization

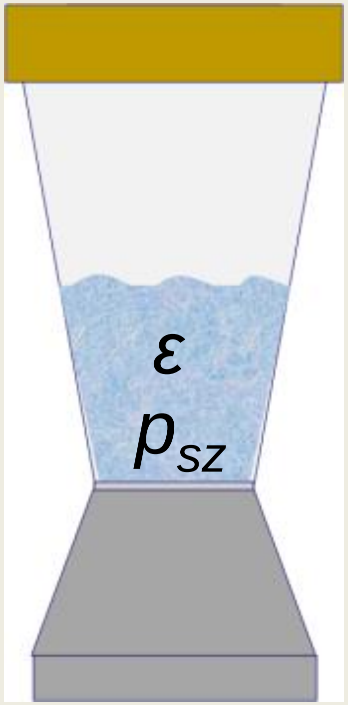
Void volume (ε)

$$\varepsilon = 1 - \frac{m_{sz}}{AL_f(\rho_{sz} - \rho_f)}$$

m_{sz} *mass of content*

A *cross-section area of the fluidizer*

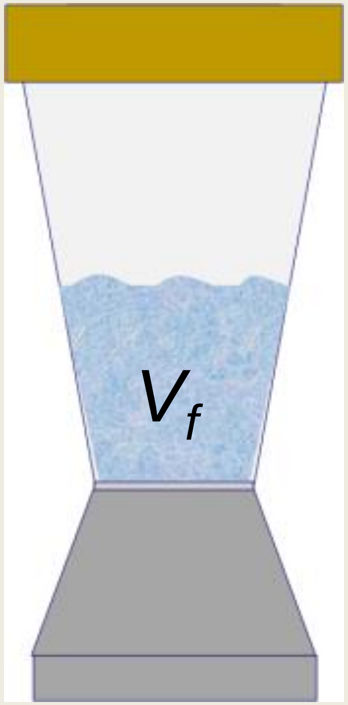
L_f *height of the fluid bed*



Parameters of Fluidization

Void volume (ε)

$$\varepsilon = \frac{V_f - V_{sz}}{V_f}$$



V_f *volume of the fluid bed*

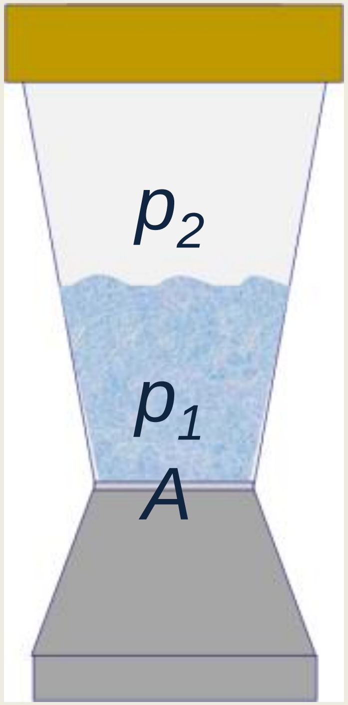
V_f - V_{sz} *volume of the void (space) between the particles*

V_{sz} *mass of the content*

Parameters of Fluidization

Pressure drop ($\Delta p = p_1 - p_2$)

$$\Delta p = \frac{m_{sz}(\rho_{sz} - \rho_f)}{A\rho_{sz}}$$



m_{sz} mass of the content

ρ_{sz} density of the fixed bed

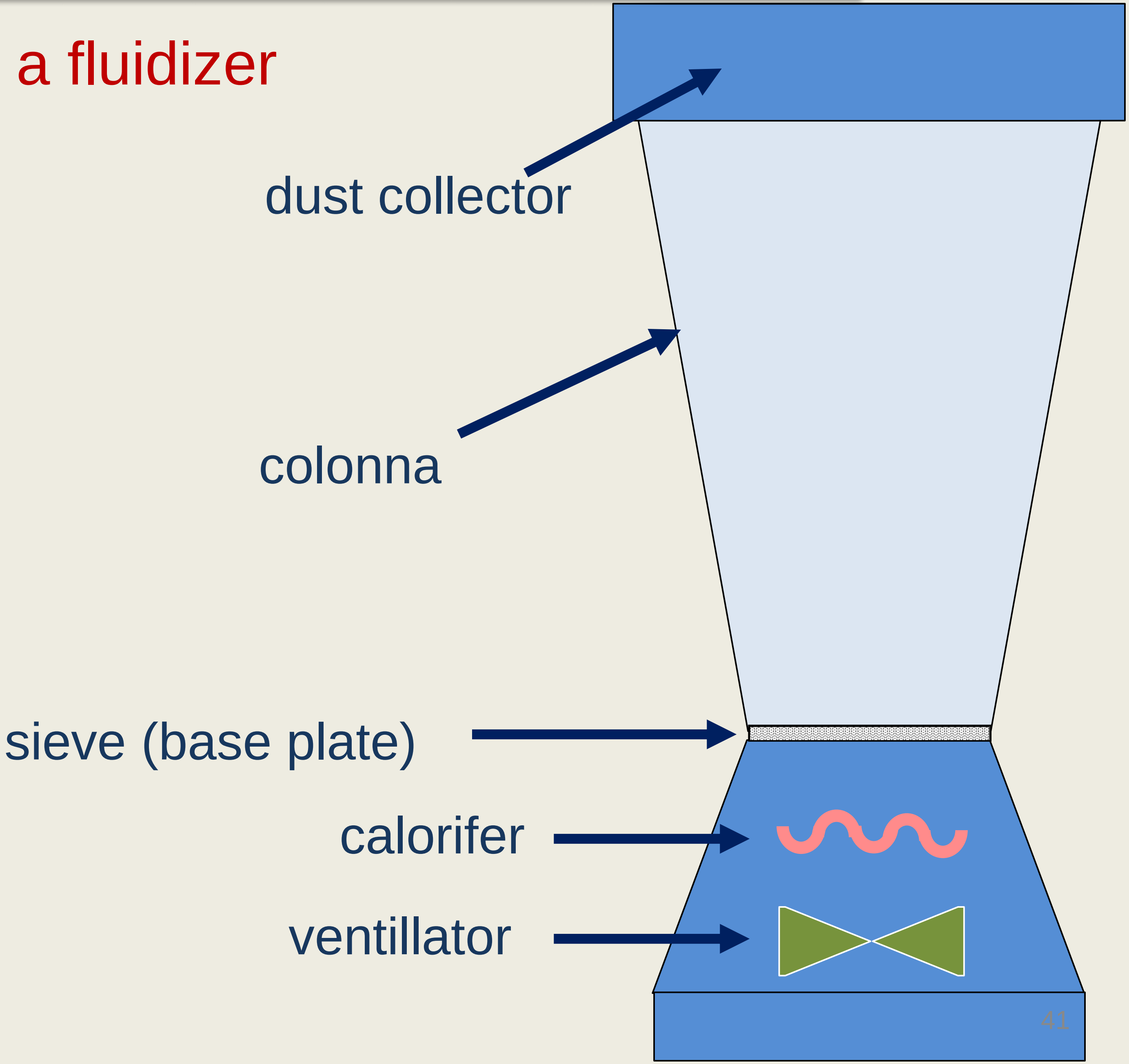
ρ_f density of the fluid bed

A cross-section area of the fluidizer

Accessories
and the
design of flidizers

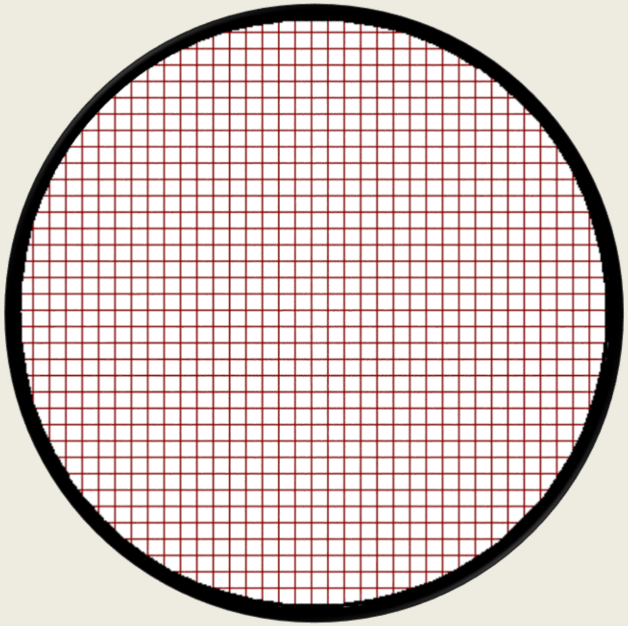
Fluidizator accessories

Mean parts of a fluidizer

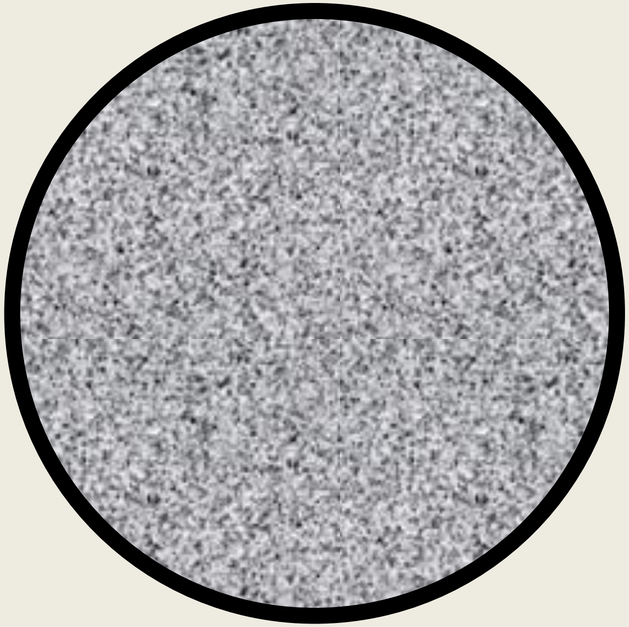


Fluidizator accessories

Base plate (sieve)



sieve

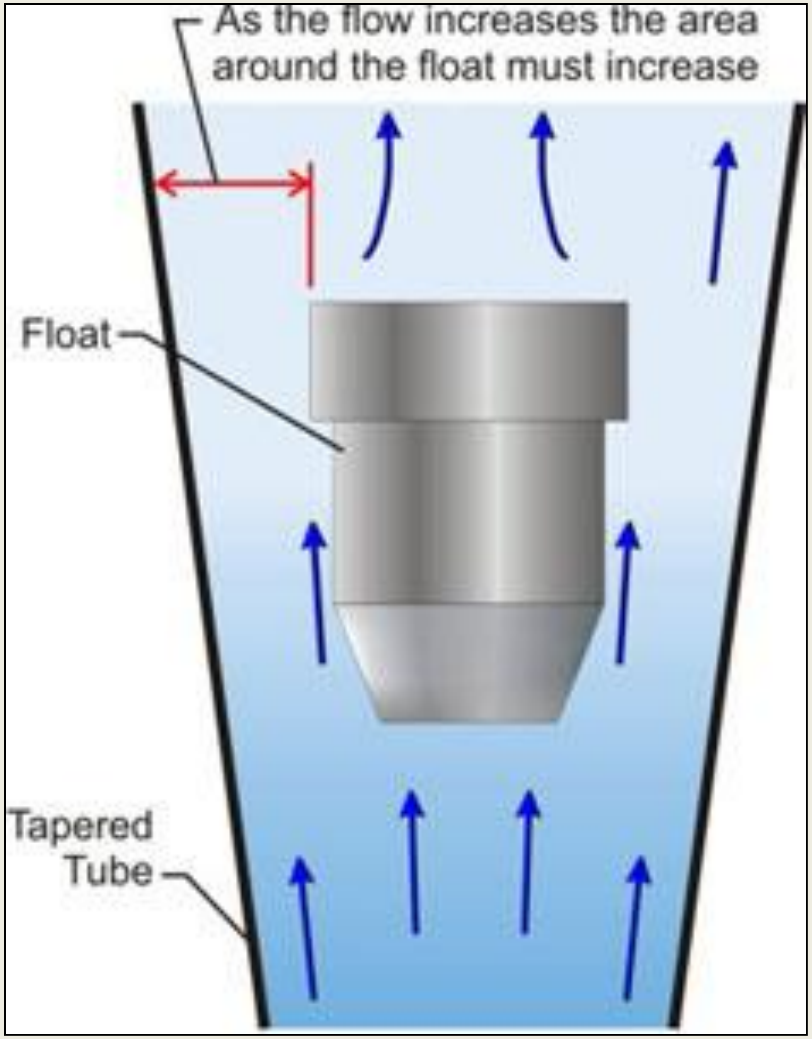


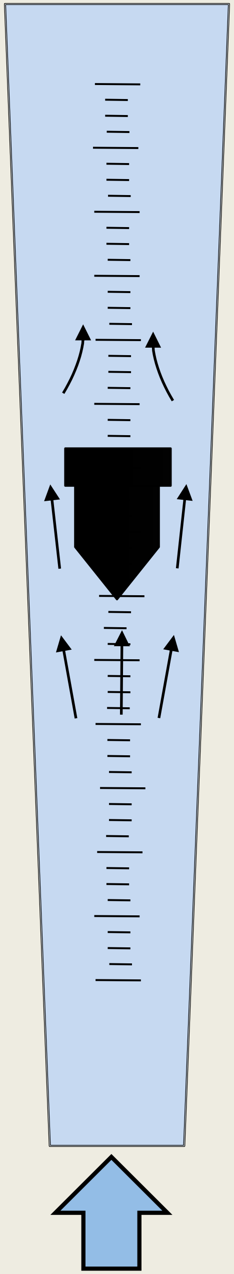
porous plate

A cross-section area

Fluidizator accessories

Rotameter





Fluidizator accessories

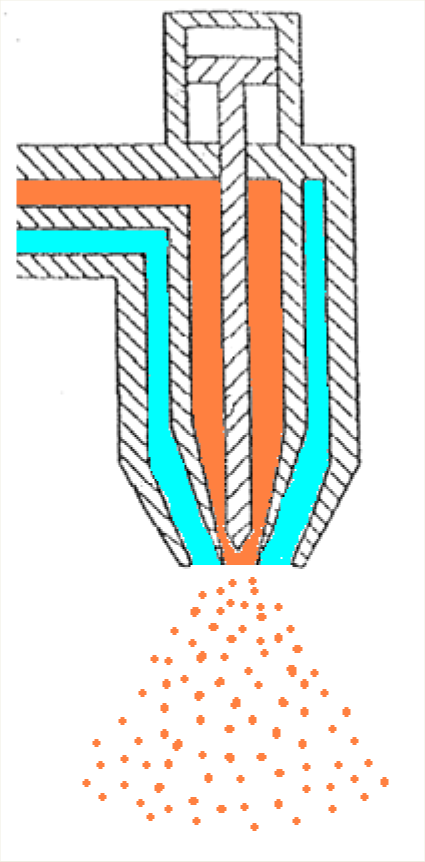
The pressure control valve

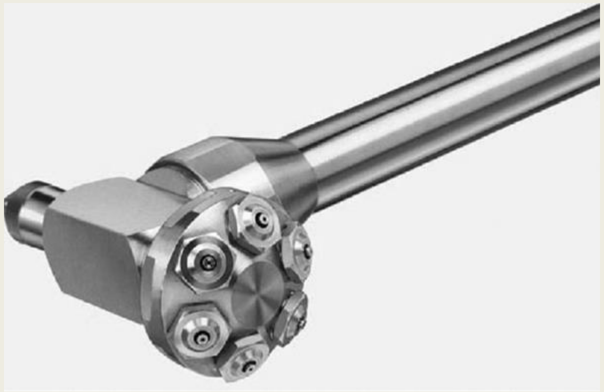
Fluidizator accessories

Spraying nozzle

liquid for granulation

air



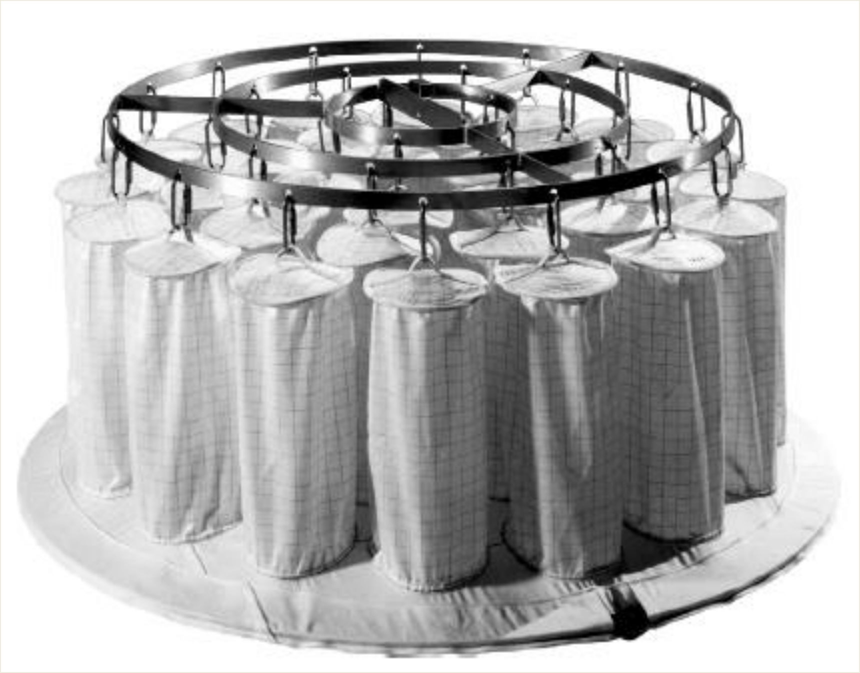


multi-headed
spraying nozzle

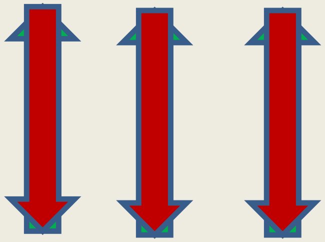
Fluidizator accessories

Dust-collector

collecting



return



Practice of Fluidization

Fluidization in practice

Equipment in the laboratory

Fluidization in practice

Equipment in the laboratory

Fluidization in practice

Equipments in the industry

- 30 kg

- 60 kg

scale-up process

- 120 kg

- 250 kg

Fluidization in practice

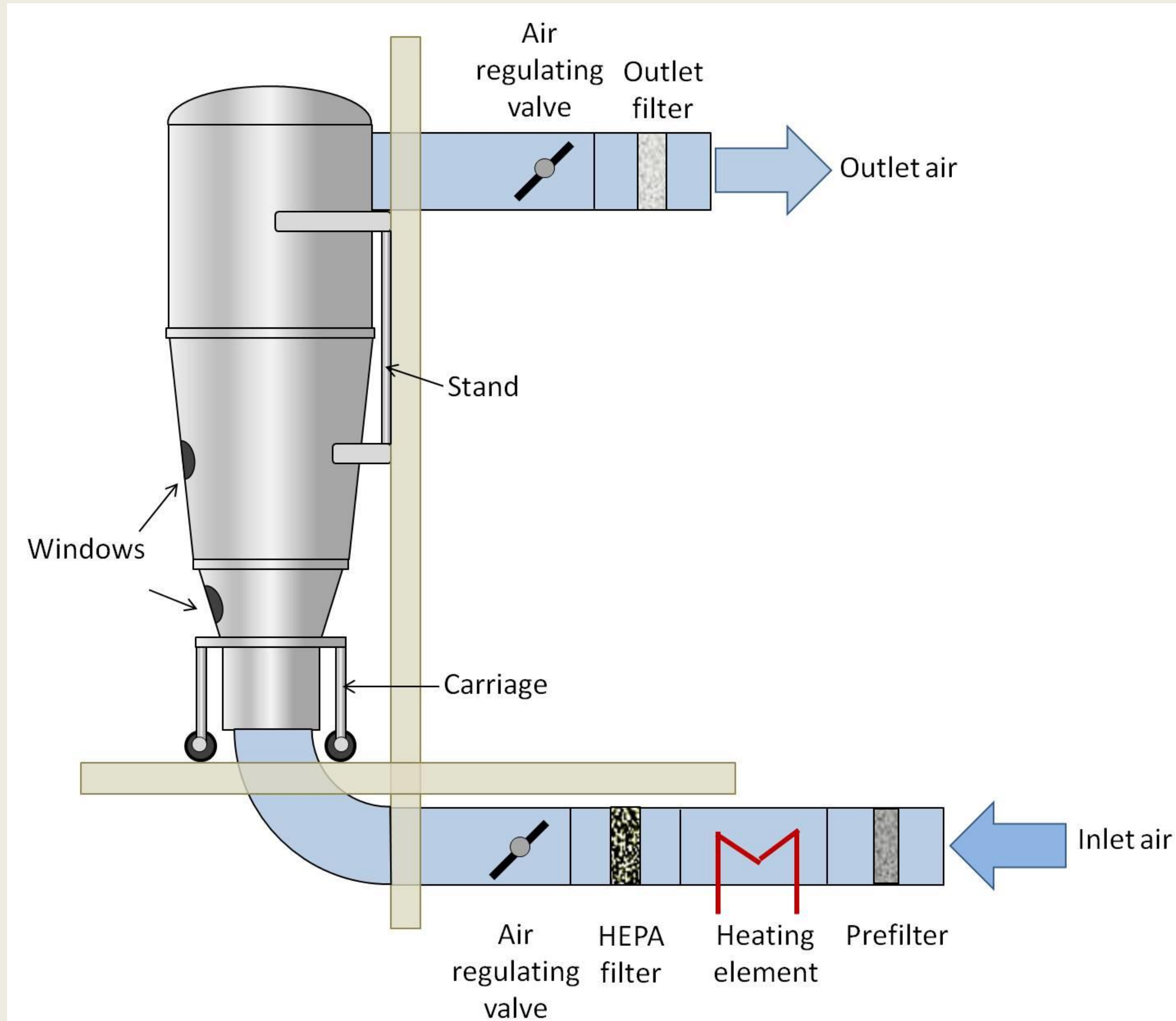
Intermittent operation

Glatt granulator

Fluidization in practice

Industrial fluidization instrument

control center



Fluidization in practice

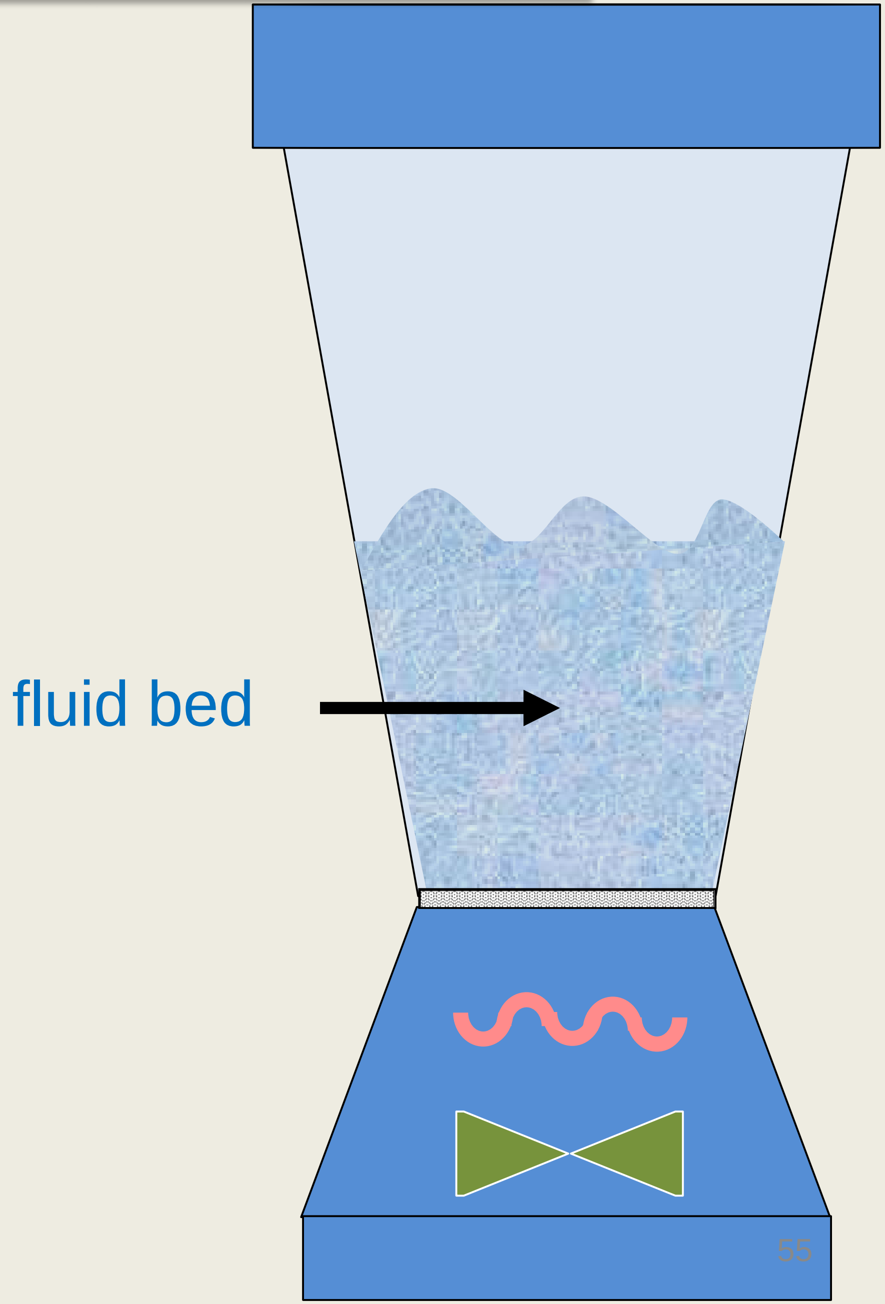
Aim of the fluidization:

- **drying,**
- **agglomeration (granulation),**
- **coating (granules, pellets, tablets).**

Drying

Fluidization in practice

Drying



Fluidization in practice

Drying with fluidization

advantages

- large contact surface
- excelent heat transfer
- the heat sensitive substancies can be dried by fluidization because of the excelent heat transfere needs a lower temperature
- good material transport (wetting-drying) – moisture sensitive ingredients

disadvantages

- powder formation
- powder flow out
- costs

Fluidization in practice

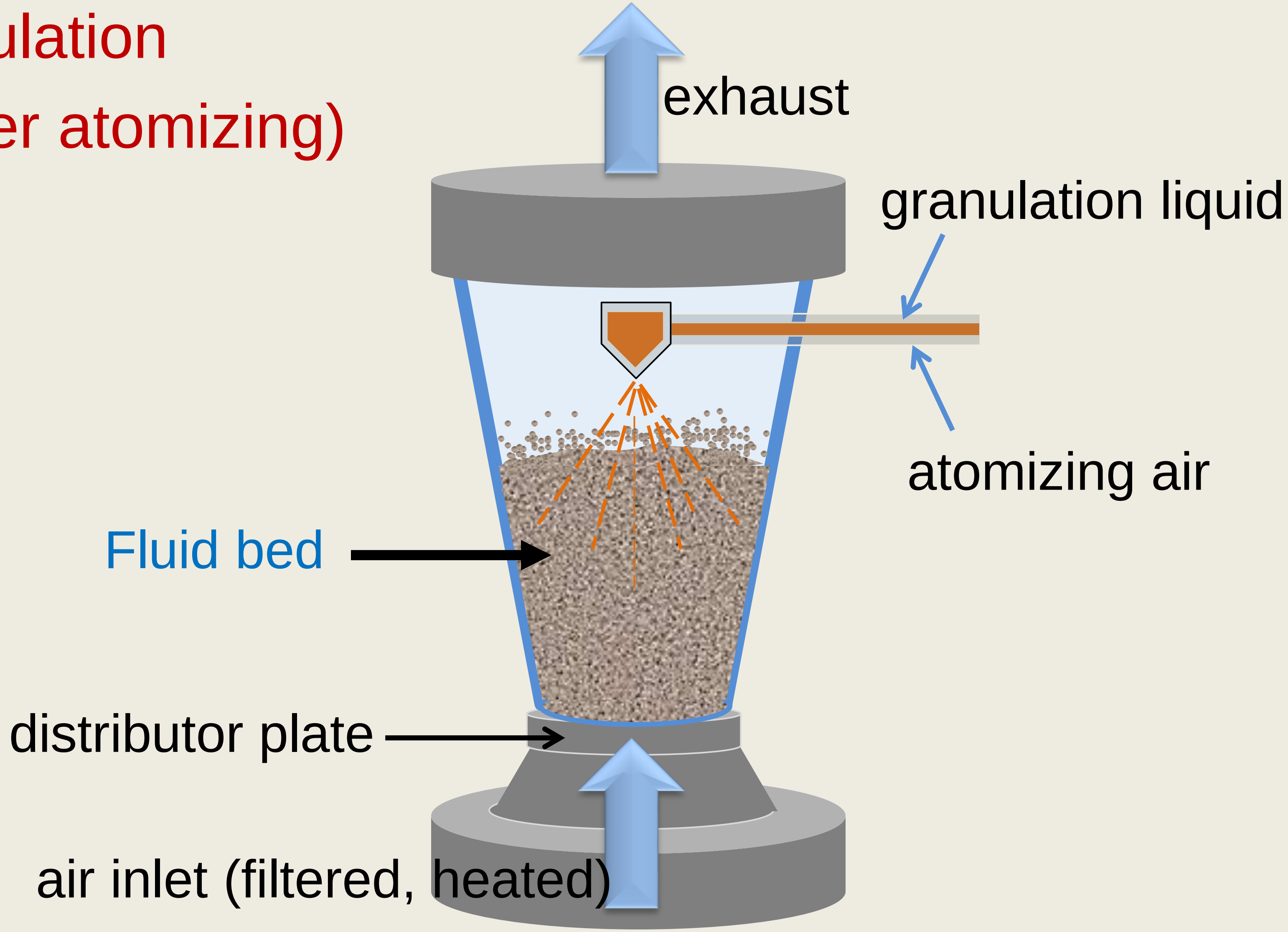
Drying with fluidization

Granulation

Fluidization in practice

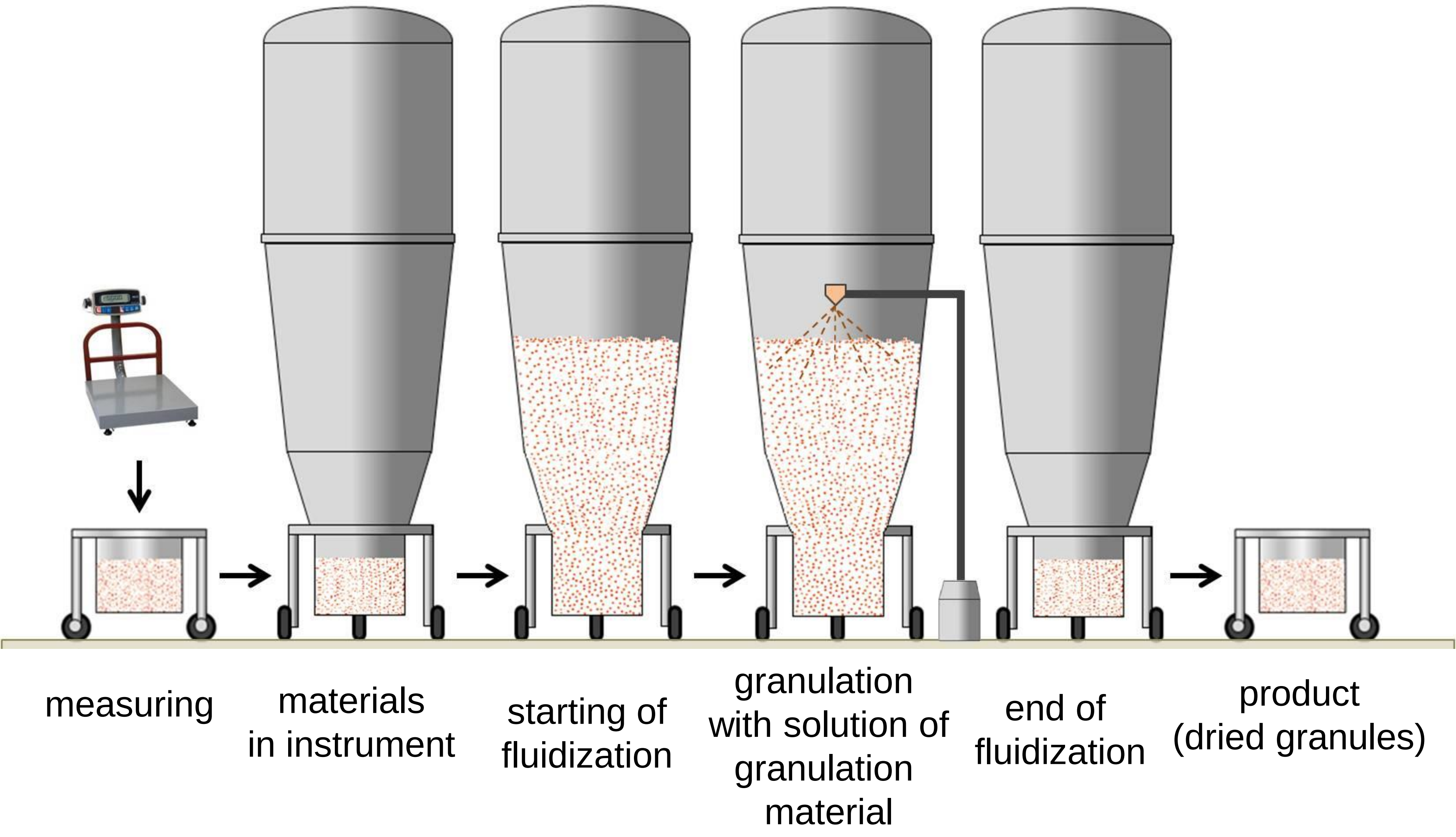
Granulation

(higher atomizing)



Fluidization in practice

Industrial fluidization instrument for granulation



Fluidization in practice

Granulation with a fluidizer

advantages

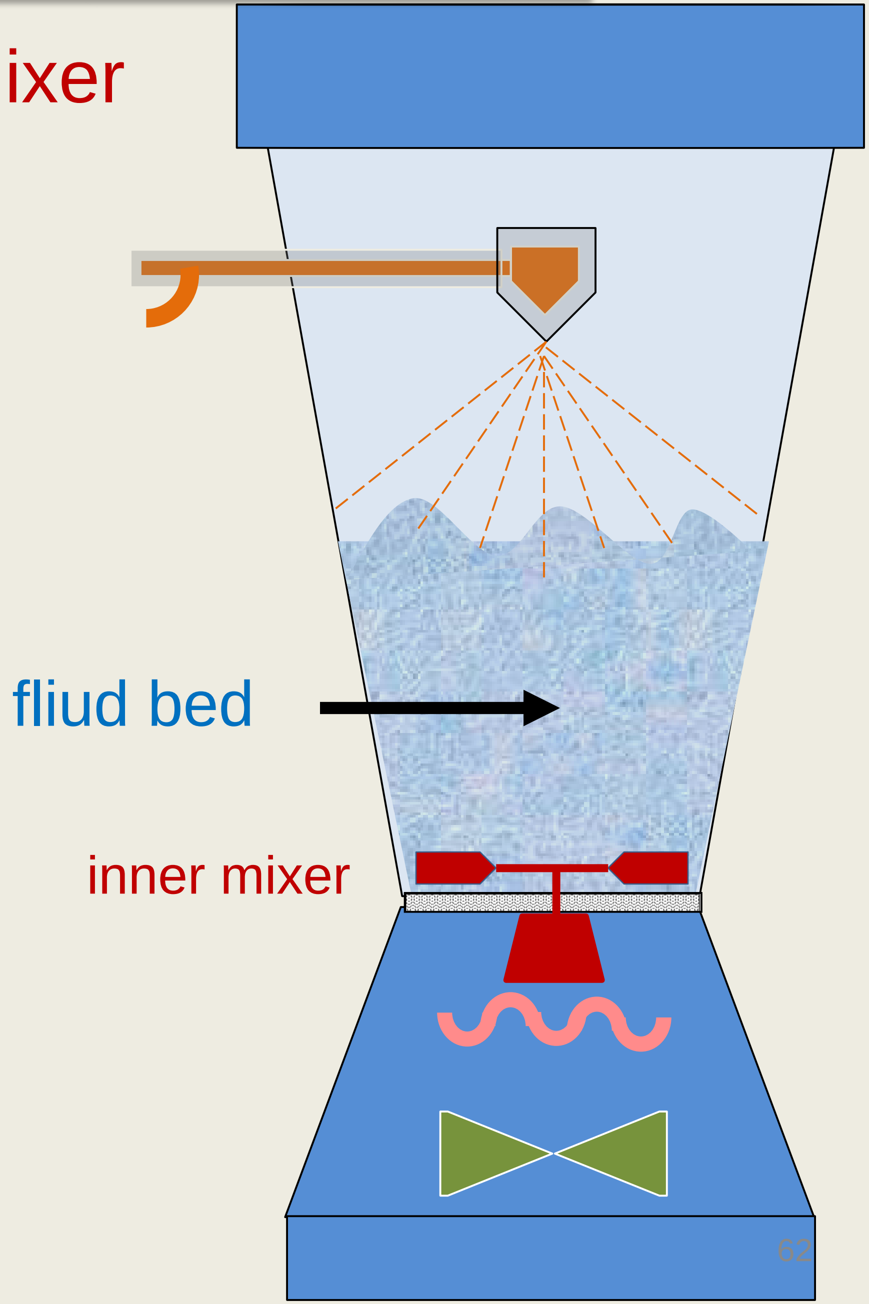
- all steps in one equipment
  (mixing, wetting, agglomeration, drying)
- huge contact surface
  (heat and material transport is very good)
  (continuous particle formation with paralell drying)

disadvantage

- inhomogenity may be occured (see the fluidization disorders)
- dust (fine powder) formation (and so flow out phenomenon)
- energy costs

Fluidization in practice

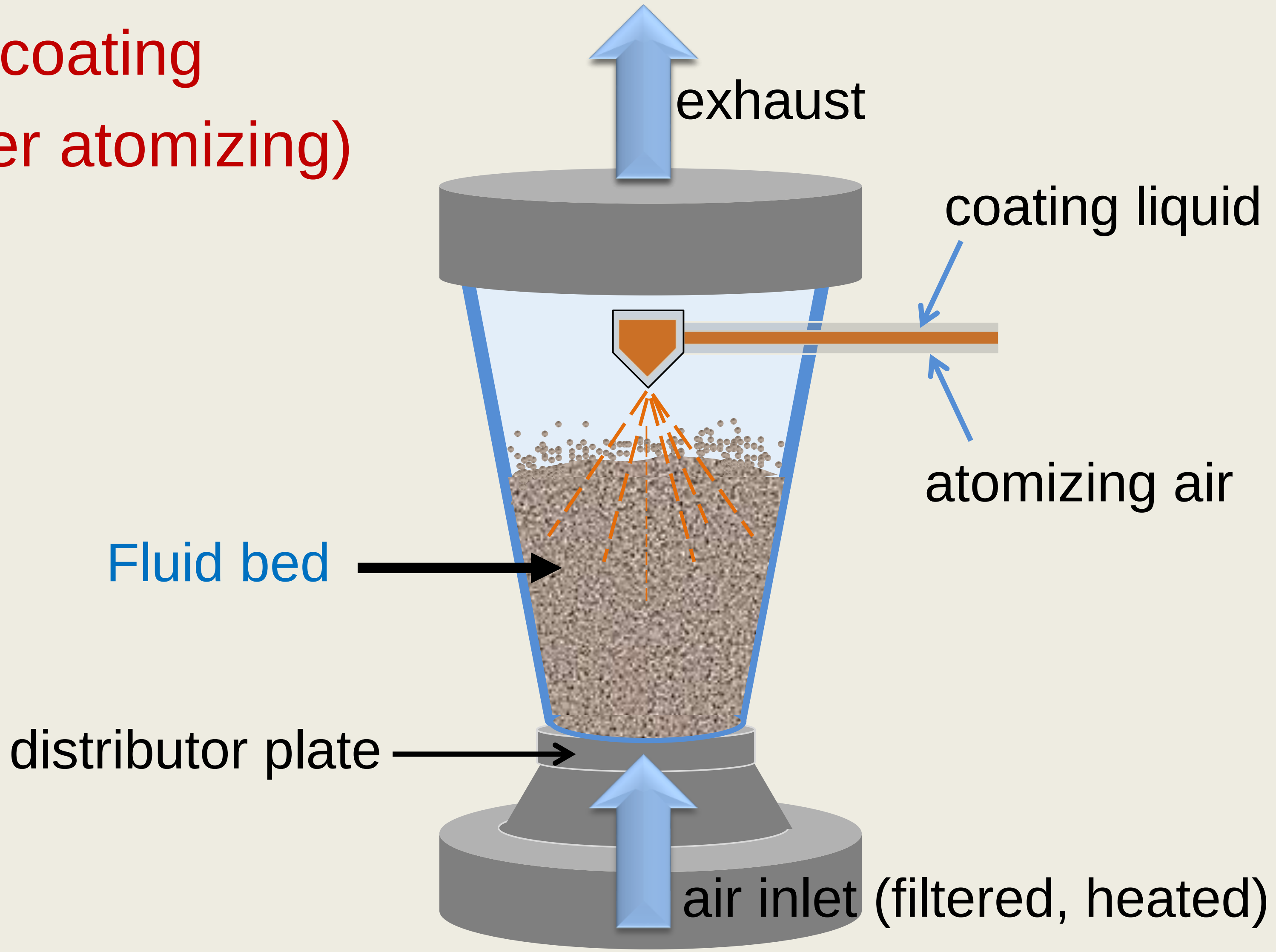
Fluid granulation with inner mixer



Coating

Fluidization in practice

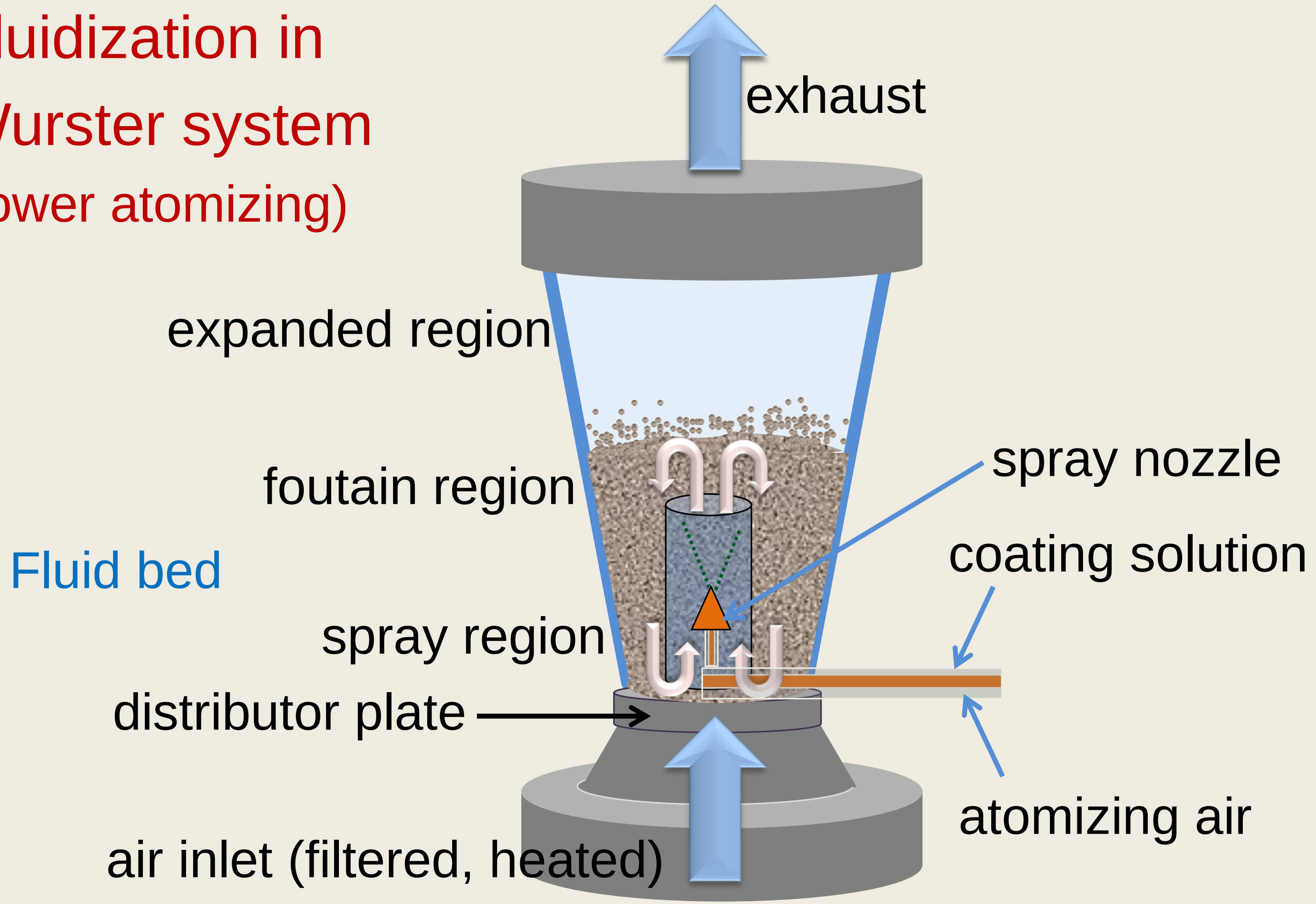
Fluid coating
(higher atomizing)



A fluidizáció gyakorlata

Fluidization in Wurster system

(lower atomizing)

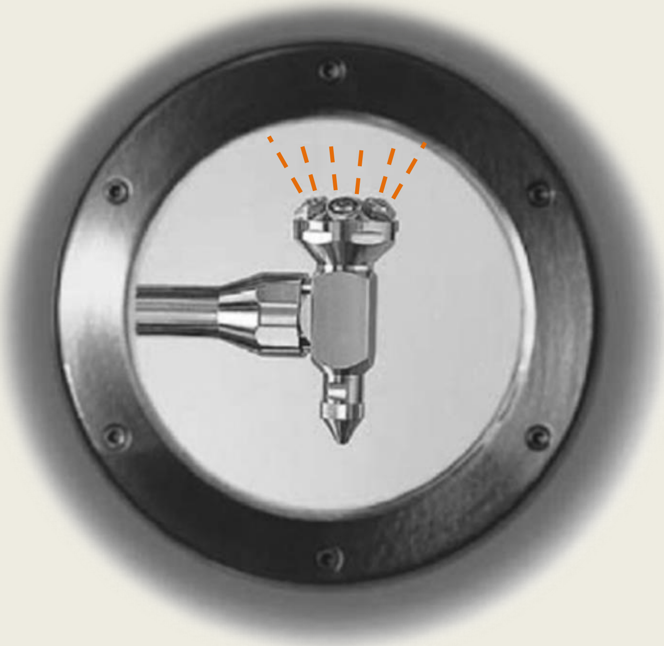


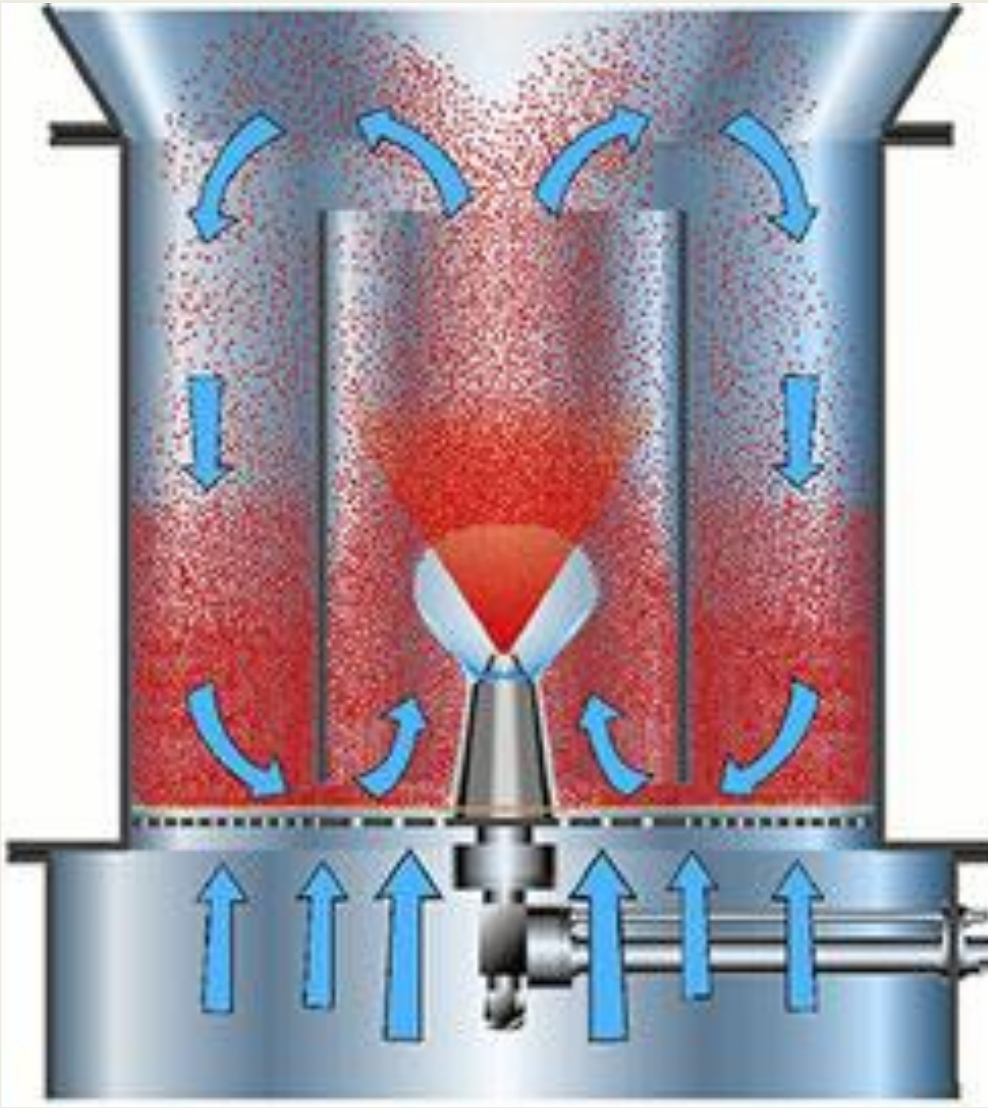
Fluidization in practice

Fluid coating

bottom spray

(Wurster)



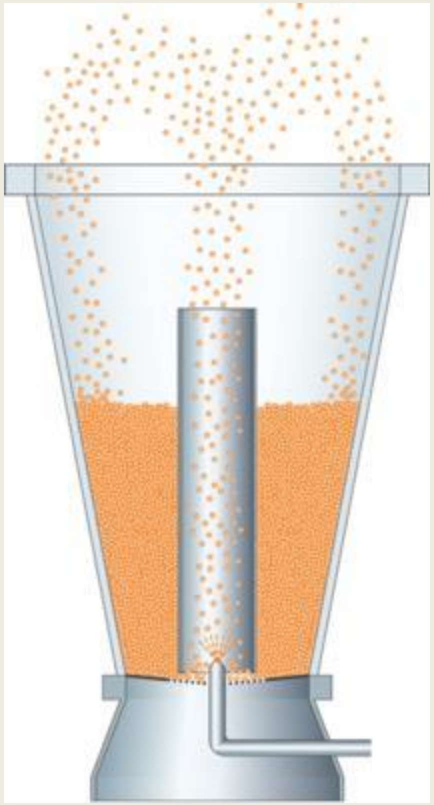


Fluidization in practice

Fluid coating

bottom spray

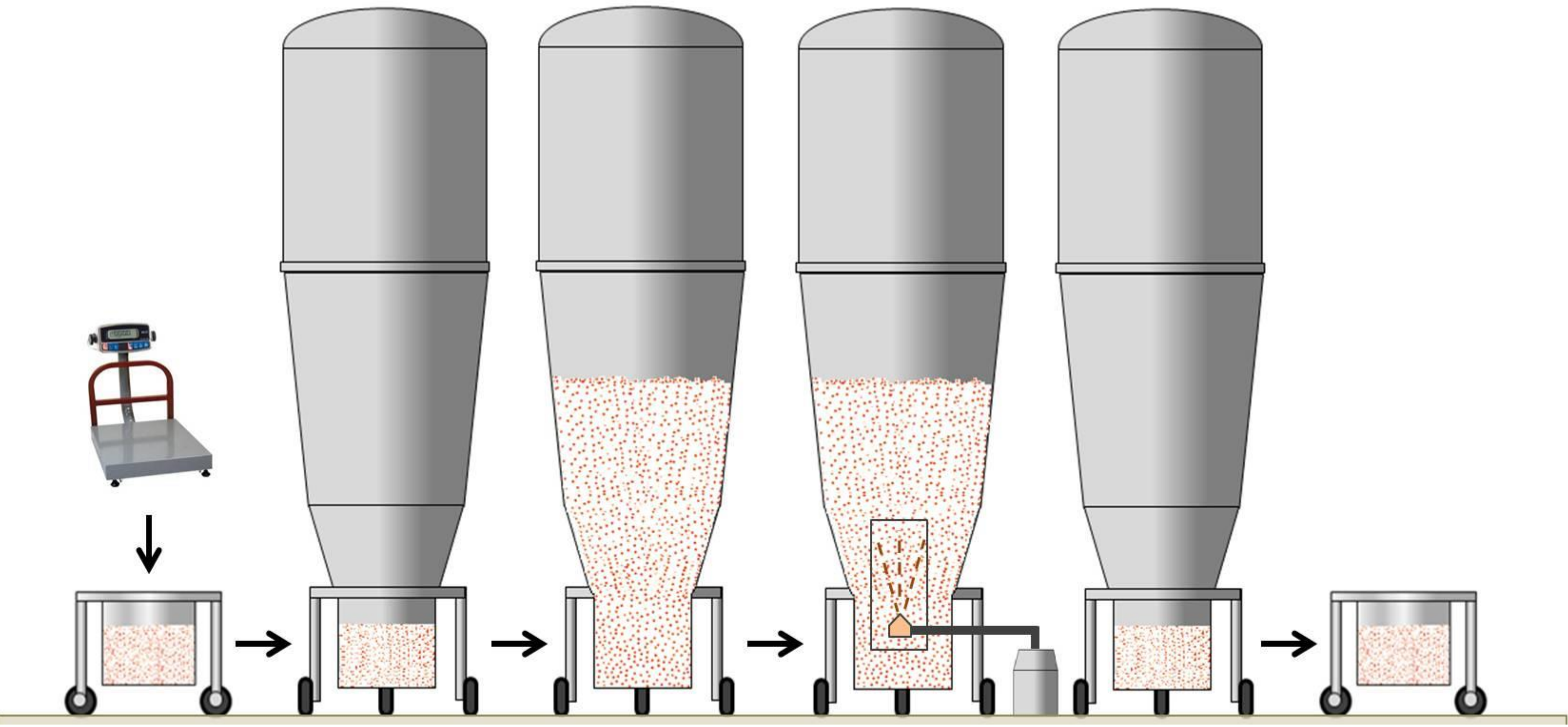
(Wurster)



Precision-Coater™ module

Fluidization in practice

Industrial fluidization instrument for coating



measuring → materials in instrument → starting of fluidization → coating with solution of coating material → end of fluidization → product (dried coated material)

Fluidization in practice

Fluid coating

advantages

- all steps in one equipment
  (mixing, wetting, multi layer coating, drying)
- huge contact surface
  (heat and material transport is very good)
  (continuous particle formation with paralell drying)

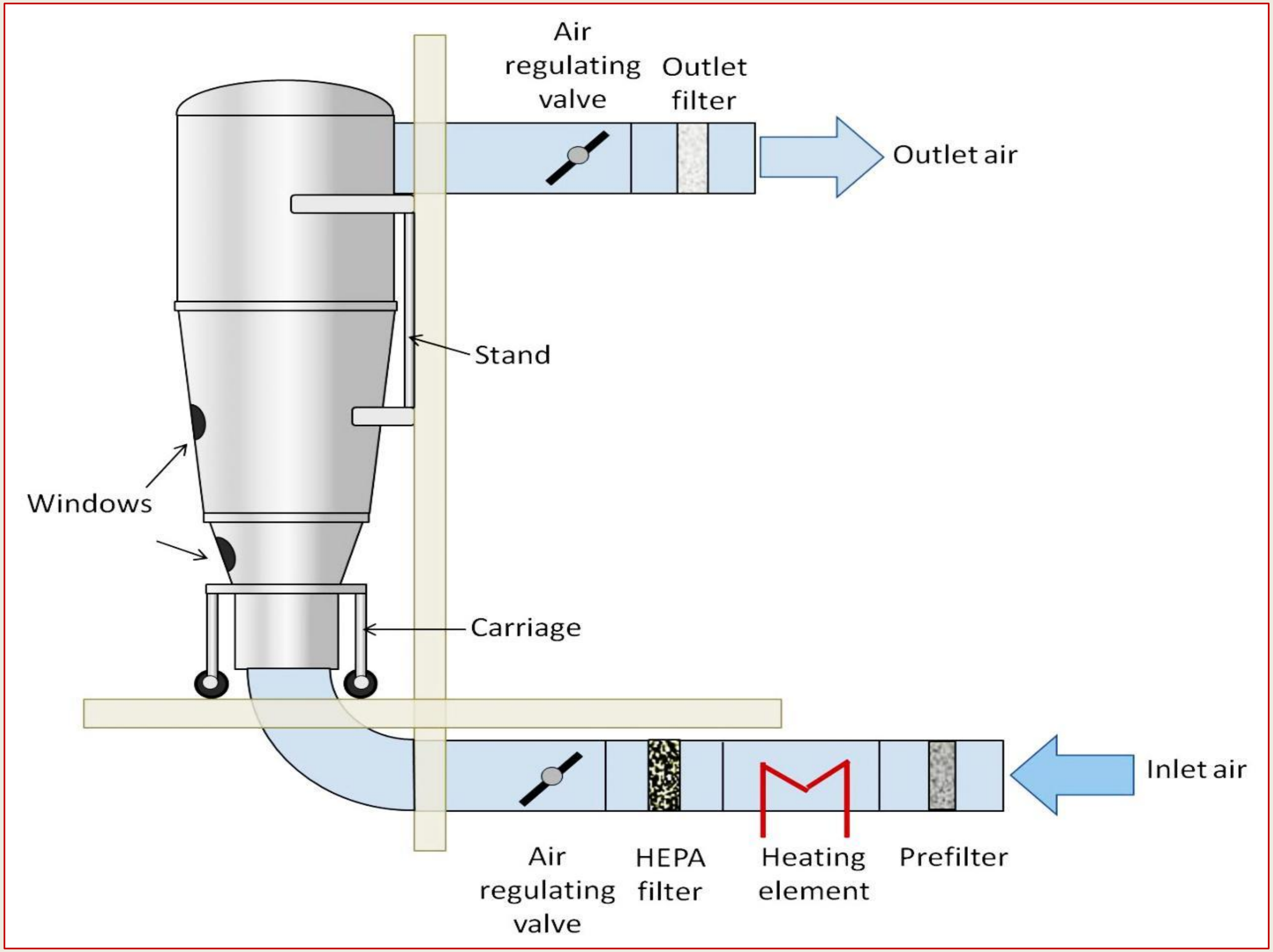
disadvantages

- inhomogenity may be occured (see the fluidization disorders)
- dust (fine powder) formation (and so flow out phenomenon)
- energy costs
- damages of the film coat
- the particles adhere to each other and also to the wall

Intermittent and continous operation

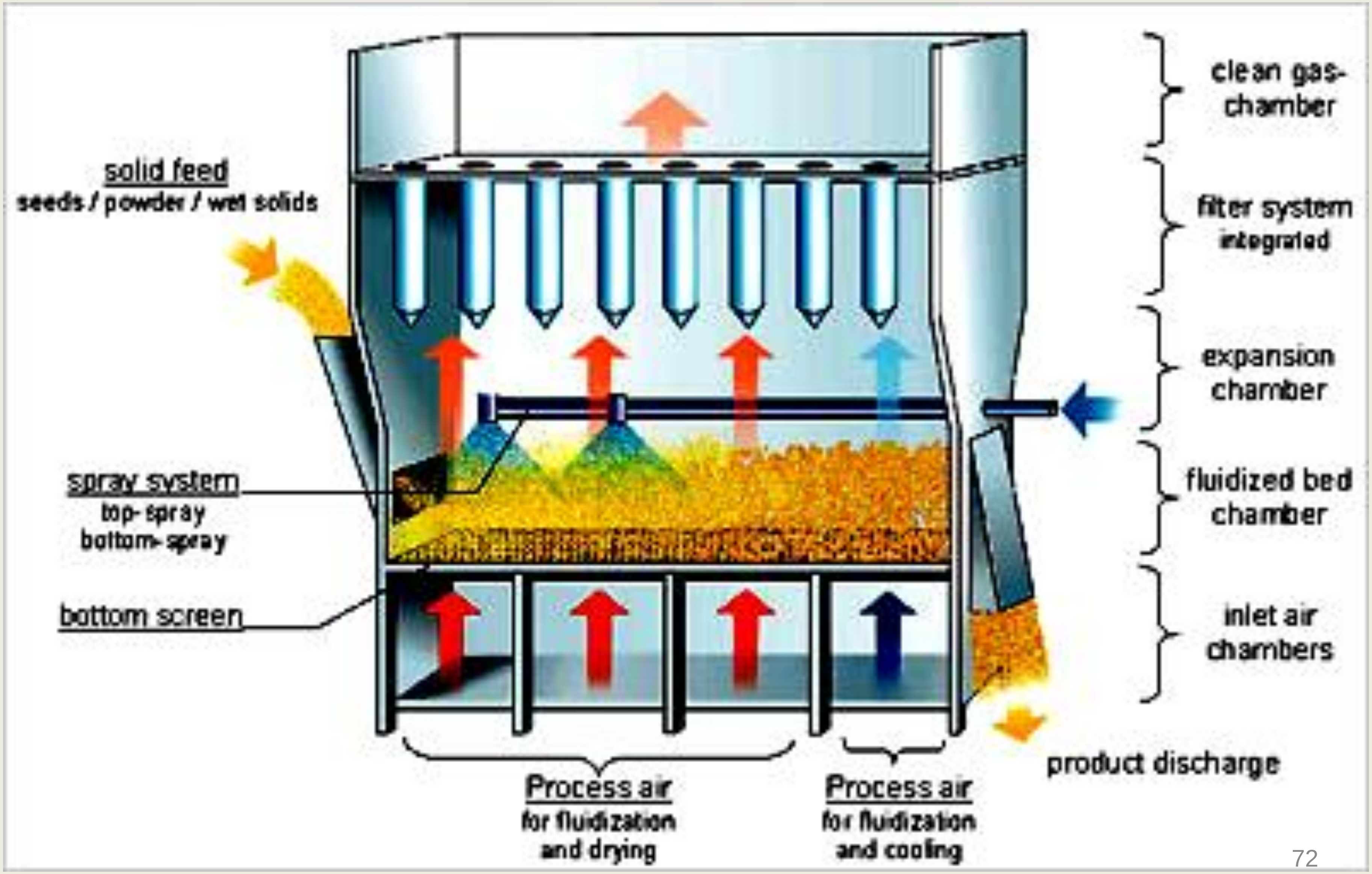
Fluidization in practice

Intermittent operation



Fluidization in practice

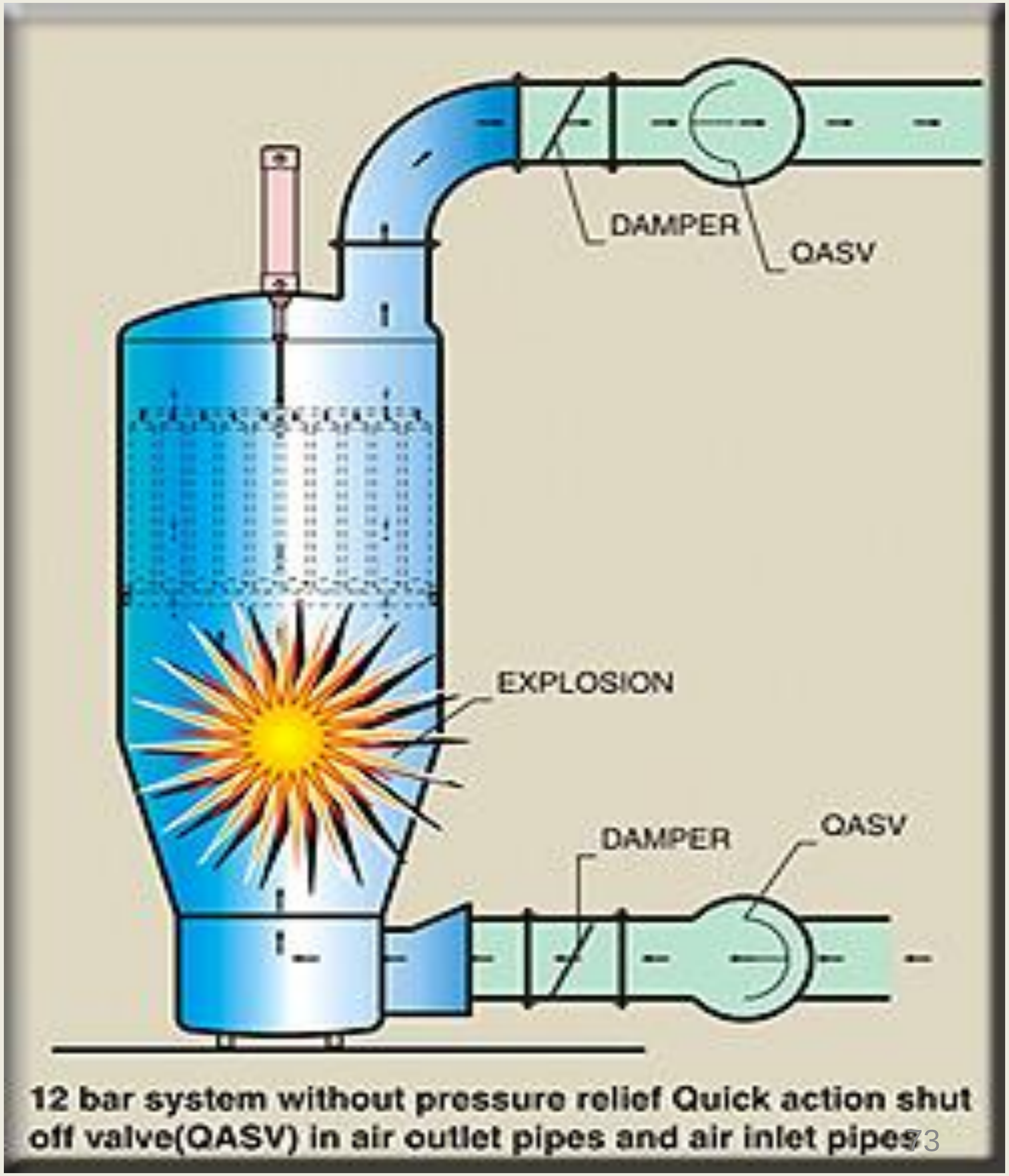
Continuous operation



Fluidization in practice

Security technology

RISK OF DUST EXPLOSION



The end